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DECEMBER 2025

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DUBAI AIRSHOW REPORT

EXPLOITING THE MOON

RAIDERS OF THE LOST ARCHIVES

EXCLUSIVE – A BRITISH MACH 2.0 CONCORDE FIGHTER EMERGES FROM THE SHADOWS

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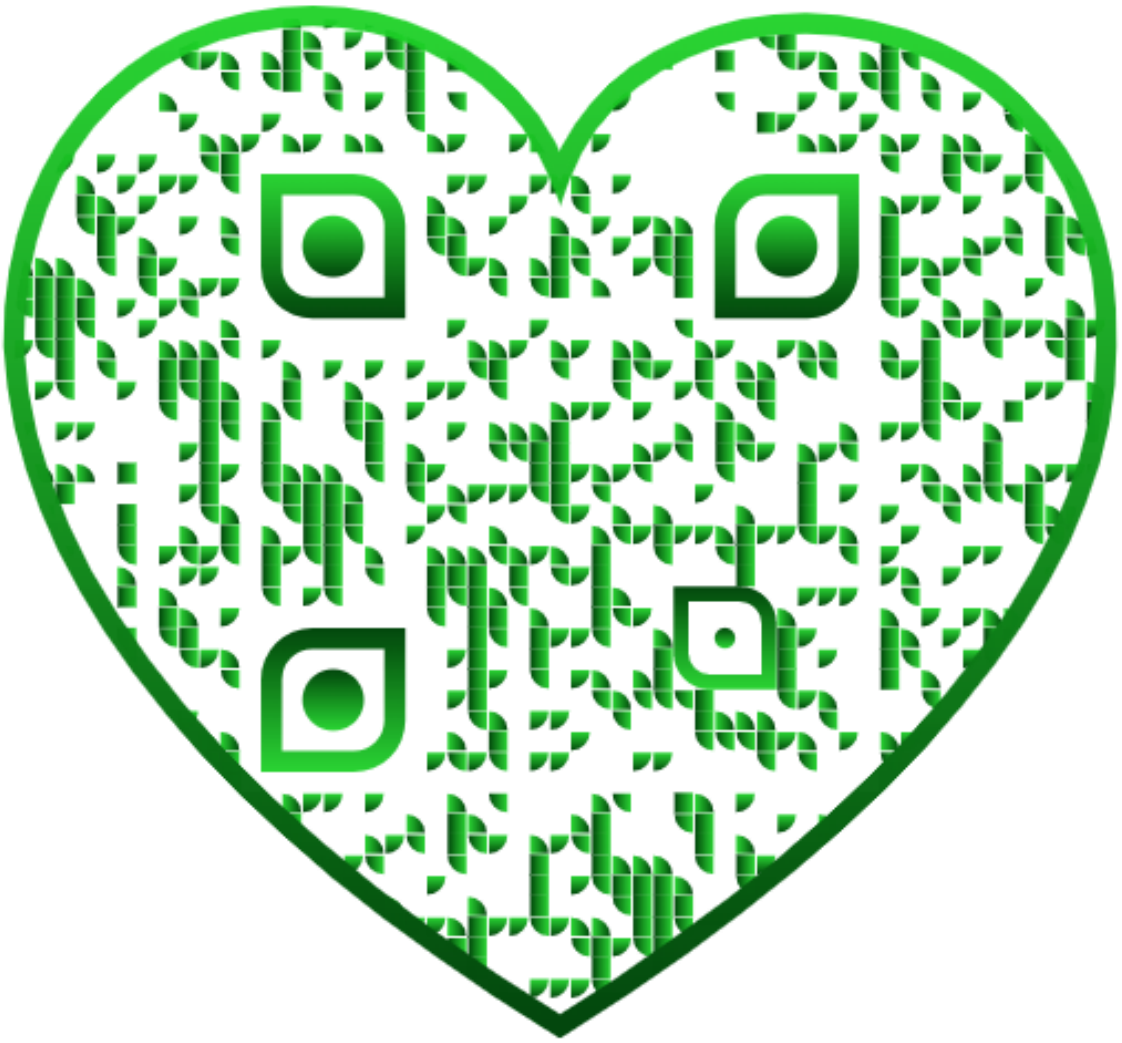

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AEROSPACE

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EDITORIAL

Risks and rewards

With the global aerospace industry facing a pressing skills crisis, its not-so-secret weapon in inspiring the next generation is the airshow – which allows young people to see, hear and smell aircraft up close and also see them perform breathtaking aerial displays. Take away the flying display from trade events or local airshows and these become no different from a plumbing convention, furniture exhibition or IT expo.

Allied to that, at international trade exhibitions and airshows there are the factors of national pride, service reputations and the pressure to show off a new aircraft to secure export sales, as well as the goal of entertaining the public through demonstration of precision flying skills. All these can conspire to tempt even experienced pilots to push themselves and their aircraft right to, or in some cases over, the limit.

This unique ability to take our breath away and plant the seed of inspiration in young minds sometimes sees display pilots pay the ultimate price to communicate their passion for flight to us earthbound mortals.

Thus, the loss of an Indian Air Force Tejas and its pilot, Wg Cdr Namansh Syal, on the final day of the Dubai Airshow is a stark and tragic reminder of the inherent risks of display flying and aviation's capacity to not tolerate the smallest error.

Airshow accidents, of course, are nothing new, but as flying display rules have tightened over the past decades and aircraft themselves have become safer overall, any fatal crashes thus become outliers and attract more eventual headlines.

The loss then, of a fellow professional aviator, in a peacetime airshow scenario, under the public gaze of a crowd expecting excitement and thrills is something that sadly brings the entire aerospace community together – whichever flag or roundel they fly under.

The risks are high in a profession where seconds separate the quick and the dead, but in that vital mission of inspiring the next generation, so are the rewards.

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Front cover: Meet Stiletto – the unbuilt British fighter derived from Concorde. (Andy Hay/www.flyingart.co.uk)

AEROSPACE INSIGHT

Additional content is available to view online at: aerosociety.com/aerospaceinsight
Including: Déjà drones, Black History Month – Five notable black aviation heroes, Attract, recruit, train, retain - People in Aerospace 2025, Would you board an AI-piloted airliner? UAS and Military Rotorcraft - Innovation and Adaptation, The Sir Maurice Flanagan archives: A giant aviation legacy.

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Blueprint

Shield AI X-Bat

Length	26ft
Wingspan	39ft
Ceiling	50,000ft
Range	2,300 miles
Manoeuvre Load Factor	4G

Launch and recovery

A concept video released by Shield shows the X-BAT deployed using a Launch/ Recovery Vehicle (LRV), based on a standard trailer truck, with wings folded in a horizontal position. A blast shield is then deployed, the wings unfold and the aircraft is raised into the vertical launch position. On recovery, the aircraft loses speed to descend on its tail and dock with the launch gantry.

Engine

The X-BAT will be powered by a GE F110-GE-129 afterburning engine as used in F-16 and F-15 fighters, but also includes an Axisymmetric Vectoring Exhaust Nozzle (AVEN) for precision vertical landings and enhanced manoeuvrability in the air. No top speed is given but a CGI concept video shows afterburner and a vapour cone.

Shield AI

Weapons

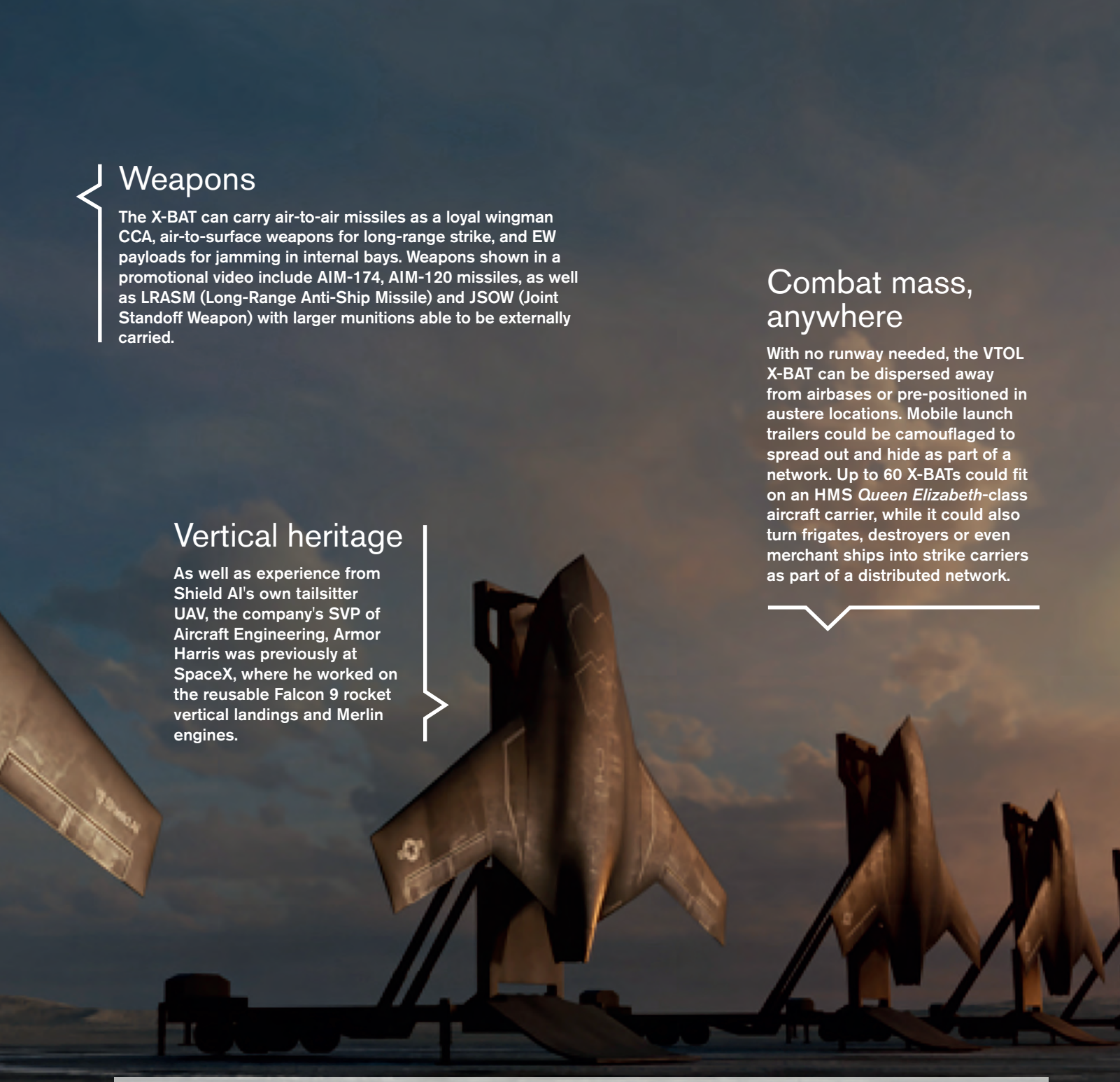
The X-BAT can carry air-to-air missiles as a loyal wingman CCA, air-to-surface weapons for long-range strike, and EW payloads for jamming in internal bays. Weapons shown in a promotional video include AIM-174, AIM-120 missiles, as well as LRASM (Long-Range Anti-Ship Missile) and JSOW (Joint Standoff Weapon) with larger munitions able to be externally carried.

Combat mass, anywhere

With no runway needed, the VTOL X-BAT can be dispersed away from airbases or pre-positioned in austere locations. Mobile launch trailers could be camouflaged to spread out and hide as part of a network. Up to 60 X-BATs could fit on an HMS *Queen Elizabeth*-class aircraft carrier, while it could also turn frigates, destroyers or even merchant ships into strike carriers as part of a distributed network.

Vertical heritage

As well as experience from Shield AI's own tailsitter UAV, the company's SVP of Aircraft Engineering, Armor Harris was previously at SpaceX, where he worked on the reusable Falcon 9 rocket vertical landings and Merlin engines.



DEFENCE

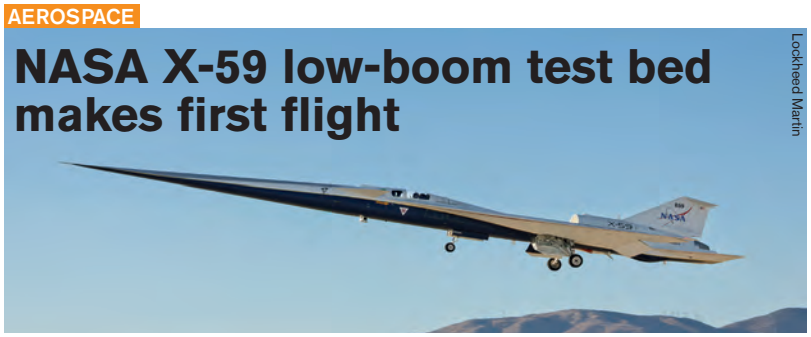
AI-powered VTOL fighter

In an unveiling ceremony in Washington DC on 22 October, US defence tech company, Shield AI revealed the X-BAT, an autonomous VTOL jet fighter CCA. The X-BAT builds on the company's previous work with its tailsitter V-Bat drone – but adds a jet engine, stealth, weapons and 2,300 mile range. It is also designed to be attritable and a 'fraction of the cost' of crewed fighters. The X-BAT incorporates the company's Hivemind AI system for full autonomous operations. Hivemind has already been tested by the USAF in the X-62A VISTA jet. Shield AI Co-founder and President, Brandon Tseng said: "Air power without runways is the holy grail of deterrence," while Armor Harris, SVP of Aircraft at the company, added: "X-BAT is a revolution in air power because it combines four things – VTOL, range, multirole capability and autonomy." First flight of the X-BAT could come in late 2026, followed by operational validation in 2028.

Radome

AEROSPACE

NASA X-59 low-boom test bed makes first flight


Lockheed Martin

NASA's X-59 Quiet Super Sonic Transport (QueSST) demonstrator took to the skies for the first time on 28 October. Built in partnership with Lockheed Martin, the X-59 flew from the historic Skunk Works' facility at USAF Plant 42 in Palmdale, California, before landing near NASA's Armstrong Flight Research Center in Edwards, California. Designed to demonstrate the ability to fly at supersonic speeds while reducing the sonic boom to a gentle 'thump', the X-59 will explore future supersonic commercial flight with data informing the establishment of new data-driven acceptable noise thresholds related to supersonic flight over land.

GENERAL AVIATION

Bonanza and Baron ride into the sunset

Textron has announced that it is ending production of its long-running and iconic Beechcraft Bonanza and Baron line of single- and twin-engined piston light aircraft. More than 7,000 Barons and 26,500 Bonanzas have been delivered since 1961 and 1947 respectively. However, according to the General Aviation Manufacturers Association (GAMA), Textron delivered just five Bonanzas and two Barons in 2024 and four Bonanzas and two Barons in the first half of 2025. A combined fleet of 13,000 are still airworthy in 2025, with Textron pledging to continue providing spares and support to owners. The single-engine Bonanza itself marks its 80th anniversary of its first flight this month on 22 December 1945. The company will now shift its focus to the turboprop, Beechcraft Denali, which first flew in 2021.

DEFENCE

Saudi Arabia gets White House nod for F-35s

Saudi Arabia is set to become the first Arabian operators of the Lockheed Martin F-35 Lightning II as US President, Donald Trump authorised a deal for the sale of 48 F-35s to the Kingdom, ahead of a visit by Crown Prince Mohammed bin Salman on 18 November. Trump said: "We will be selling F-35 jets; they've been a great ally." The move represents a major shift in long-standing US security policy to restrict the export of the most advanced military technology elsewhere in the Middle East to retain Israel's qualitative military edge as the only nation in the region to field F-35s. However, the potential export saw some US officials raise concerns over Riyadh's closeness with China and the possibility that F-35 secrets could leak. A previous bid in 2021 by the UAE to acquire 50 F-35s was blocked by the US.

AIR TRANSPORT

Air Astana

Air Astana in biggest ever fleet order

Kazakhstan flag carrier, Air Astana has placed the biggest ever order in its history, with an MoU for up to 50 Airbus A320neo airliners. The deal splits into 25 firm and 25 options, with a mix of A320neos and A321LRneos. First deliveries will begin in 2031.

NEWS IN BRIEF

Honeywell Aerospace has unveiled new software designed to enable aircraft to accurately navigate when global navigation satellite system (GNSS) signals are degraded, jammed or spoofed. The Honeywell Alternative Navigation Architecture (HANA) can be used by both crewed and uncrewed aircraft and uses a combination of sensing systems in a layered architecture. These include magnetic anomaly-aided navigation and the use of live camera feeds matching ground imagery with map databases.

Japan Airlines is making moves to modernise its regional fleet, with the potential of purchasing up to 70 new aircraft. According to *The Japan Times,* JAL is looking to add up to 40 single-aisle and 30 turboprops and is considering both the Airbus A220 and Embraer E2 jets. A final decision is set to be made by the end of the fiscal year, with the goal of slimming the number of types operated by the carrier.

Joby Aviation and L3Harris have conducted the first test flight of a hybrid-electric VTOL aircraft developed for military applications, such as ISR, logistics and rotary CCAs. Based on the Joby's S4 eVTOL, the flight took place on 14 November at Joby's Marina, California facility.

Europe is developing its very own spacesuit. Designed by French sportswear company, Decathlon, ESA astronaut, Sophie Adenot will test the intra-vehicular activity (IVA) suit during her 2026 trip to the ISS. The prototype, dubbed EuroSuit, was developed in collaboration with CNES, Spartan Space and Medes. Boasting several technological advancements, Decathlon said the suit can be donned or removed in under two minutes.

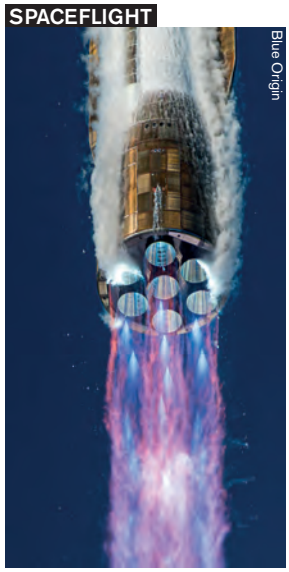
Textron Aviation's Cessna 560XL Citation Ascend was granted FAA type certification on 5 November. The two flight test aircraft completed more than 1,000 flight hours before achieving certification. Compared to earlier variants, the 12-seat Ascend has an entirely

AIR TRANSPORT

Whitehall selects Heathrow £49bn expansion plan

The UK's Transport Secretary, Heidi Alexander MP, has officially selected Heathrow Airport's £49bn proposal as the choice for the airport's third runway and expansion. The company, which manages the airport, plans to build a privately-financed £21bn, 3,500m long third runway, £12bn for a new 'T5X' terminal and a final £15bn for an overall modernisation of the airport, with the ultimate plan to accommodate 150m passengers per year. Heathrow beat the opposing bid from Arora Group, which hoped to initiate a cheaper and less invasive expansion. Alexander said that the government is determined to make the scheme "cost-effective, minimising the burden on passengers and coming at no cost to the taxpayer."

SPACEFLIGHT

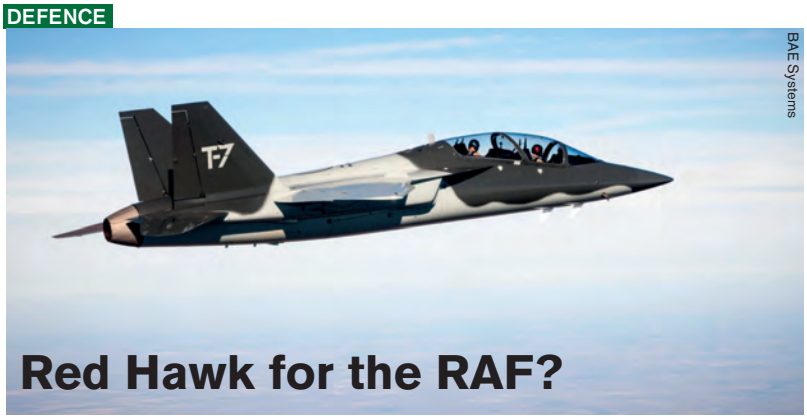


Blue Origin

New Glenn aces second flight with perfect landing

After several delays, Blue Origin successfully launched its second two-stage new Glenn rocket and also completed the landing of the reusable first stage. The mission, deploying NASA's Escape and Plasma Acceleration and Dynamics Explorers (ESCAPADE) twin-spacecraft, launched on 13 November from Launch Complex 36 at Cape Canaveral Space Force Station. Nine minutes after lift-off, the first stage, dubbed *Never Tell Me The Odds*, made a controlled landing on the cargo ship, *Jacklyn*, in the Atlantic Ocean. The launch was deemed a success for being the largest rocket stage – just under 60m in height – to complete a controlled landing on its second try, almost a decade after Blue Origin landed its suborbital New Shepard rocket for the first time in 2015.

DEFENCE



BAE Systems

Red Hawk for the RAF?

On 18 November, BAE Systems, Boeing and Saab announced they were collaborating on the RAF's fast-jet trainer programme to replace the Hawk. The three signed a Letter of Intent (LoI) to develop the system, integrate live and synthetic training capability and associated mission systems, with the T-7 Red Hawk as the core. The proposal includes final assembly in the UK.

AEROSPACE

HAL signs MoU to build Superjet in India

Hindustan Aeronautics (HAL) has signed an MoU with Russia's United Aircraft Corporation (UAC) to produce the latter's Sukhoi Superjet 100 airliner in India. The in-person signing in Moscow came just days after US President, Trump imposed additional tariffs on India for not cutting its Russian oil imports. If implemented this would be the first time in three decades that a complete civil airliner will be assembled in India, the last being the licence-built Avro HS-748 turboprop, which ended production in 1988. Under the deal, local production of the Superjet would initially be aimed at domestic Indian operators, to satisfy the growing demand in the country's regional market, with over 500 aircraft estimated to be needed for domestic (200) and short-haul international flights (350+) over the next decade.

new cockpit equipped with Garmin G5000 avionics, including autothrottles and advanced weather detection/avoidance technology.

Boeing Digital Aviation Solutions (BDAS) has completed the sale of its Jeppesen, ForeFlight, AerData and OzRunways digital products to private equity firm, Thoma Bravo for $10.55bn. The businesses will operate as Jeppesen ForeFlight and be led by former head of BDAS, Brad Surak.

Airbus has announced that Korean Air has converted orders for seven of the 27 A350-1000s placed in 2024 to the A350F freighter. Initially part of an order for 27 A350-1000s and six A350-900s, the Korean flag carrier will now only receive 20 of the former.

A Turkish Air Force C-130E Hercules cargo aircraft broke up in the skies over Georgia on 11 November, falling to the ground in multiple pieces. The aircraft was flying from Azerbaijan to Türkiye at 24,000ft at the time of the accident with 20 crew and passengers aboard.

Chinese commercial space firm, Space Pioneer has conducted satellite separation tests for its TL-3 carrier rocket. The Zhangjiagang-based company has steered away from traditional explosive bolts and other pyrotechnic devices in favour of a memory-shape alloy unlocking mechanism which it says is 60% lighter, 70% cheaper and reduces the risk of strong impact and contamination to the carrier rocket.

Due to a shortage of qualified FAA Designated Pilot Examiners (DPE), the agency is reportedly planning to support US flying schools to examine their own PPL students. According to a memo, cited by *Avbrief*'s Russ Niles, only 74 of the 509 schools in the US have the authority to conduct their own testing and the FAA plans to "proactively support examining authority for eligible and qualified schools" by reducing the amount of oversight required to assess whether flight schools can qualify to do their own testing.

Radome

DEFENCE

Anduril's Fury CCA flies for the first time

Anduril's YFQ-44A, dubbed Fury, completed its first flight on 31 October, at Southern California Logistics Airport kicking off its flight-testing campaign. It comes months after competitor, General Atomics' YFQ-42A completed its first flight in August. "Anduril and the US Air Force began flight testing at record speed, taking the YFQ-44A from clean-sheet design to wheels-up in just 556 days," the company said in a statement. Its semi-autonomous capability, delayed its maiden flight, which was originally supposed to take place during the summer. As flight testing begins, Anduril also said it is building a 5m sq ft production facility, called Arsenal-1, in Columbus, Ohio, where it will manufacture the first Fury CCAs in the first half of 2026.

AEROSPACE

StopRotor VTOL airliner proposal

Inoviation

French start-up, Inoviation has announced plans to combine NASA StopRotor technology with proven airframes to create super-efficient VTOL regional air mobility platforms. The company's ePC-12 and eATR 52 are based on Pilatus' PC-12 and the familiar line of ATR turboprops but will both be fitted with elongated wings that double up as rotors. The 52-seat eATR52 will have a 156ft 6in span, including a pair of 68ft 11in rotors doubling up as the outer portion of the wing in forward flight to provide a projected range of 575 miles.

GENERAL AVIATION

UK bid to reclaim seaplane speed record

Seablade

Although the Supermarine S6B famously won the Schneider Trophy and established a world speed record for piston-powered seaplanes (of 407.5 mph) in 1931, the record was snatched by the Italian Macchi MC72, which nudged it up to 440.681mph in 1934. Now, a team of UK designers, builders and pilots plan to regain the record. The Seablade has been designed by Prof Andrew Rae FRAeS of the University of the Highlands and Islands, and – as with the S6B – power will come from a Rolls-Royce engine. The aircraft will be fitted with a Griffon 87, driving contra-rotating propellers, which is hoped will push the all-composite seaplane to in excess of 500mph.

AIR TRANSPORT

Wizz Air scales back A321XLR long-haul plans

On 7 November, Hungarian low-cost carrier, Wizz Air announced that it had reached an agreement with Airbus to defer deliveries for 88 new aircraft from 2030 to 2033. It is also reducing its commitment to the A321XLR variant from 47 aircraft to just 11 – including the five it already has in service. The remaining 36 orders will now be converted to standard A321neos. "We learned that ultra-long-haul on narrowbodies is a niche too far for our cost base," CEO, József Váradi told investors during the airline's Q2 earnings call. Meanwhile, the carrier announced plans to trial a new premium seating product. 'Wizz Class', which will see the middle seat blocked in selected rows, will be trialled in December.

NEWS IN BRIEF

UK eVTOL developer, Vertical Aerospace has received its Permit to Fly for the VX4 from the UK CAA and begun testing the transition phase from hovering to wingborne flight. Testing, in the hands of test pilot, Paul Stone, began on 13 November and the company says it remains on track to complete transition testing by the end of 2025.

China's Guangzhou Baiyun International Airport has opened its third terminal and fifth runway, becoming the nation's first civil airport with five commercial runways. Officials say it now has the potential to handle 120m passengers and 3.8m tonnes of cargo and mail each year.

Embraer has expanded the mission portfolio for the A-29 Super Tucano to counter uncrewed threats. Fitted with a new Electro-Optical/ Infra-Red (EO/IR) sensor for laser tracking and designation sensors and datalinks for receiving initial target co-ordinates and cueing, the variant can then use laser-guided rockets and the wing-mounted .50cal machine guns to neutralise UAVs.

On the ISS' 25th anniversary, NASA historian and engineer, Ben Feist, and NASA contractor, David Charney, have built a new website, allowing users to watch multimedia from any day selected over the past two and a half decades on the station. The site, called 'ISS In Real Time,' contains 9,127 days of mission data, full space-to-ground communications coverage, calls from astronauts to ground stations and over 6m photos taken in space.

China's United Aircraft Corporation successfully test flew its T1400 Boying tandem rotor UAV at Harbin on 30 October. Resembling a scaled-down Chinook, the vehicle has a MTOW of 3,100lb, a cruise speed of 97kts, a ceiling of 21,000ft and an endurance of eight hours. The twin-engined UAV is designed for "agricultural protection, logistics transportation and forest fire prevention."

Australian hypersonic flight pioneer, Hypersonix Launch Systems has received £22.8m in Series A funding from the National Reconstruction Fund Corporation, Queensland

AIR TRANSPORT

Riyadh Air touches down in London

Riyadh Air

Saudi Arabia's newest airline, Riyadh Air, completed its inaugural passenger flight on 26 October to London Heathrow Airport. The airline, founded in March 2023, completed the maiden flight with a Boeing 787-9 Dreamliner, named *Jamila*, which was a former Oman Air-owned jet. The flight, which departed King Khalid International Airport Riyadh at 03:15 and landed in London at 07:30, carried only company employees and select groups, according to the airline. The airframe is currently the airline's only aircraft, as it waits for over 100 aircraft currently on order, including more 787s, Airbus A321neos and A350s.

DEFENCE

Typhoon and Rafale get export boosts

On 27 October, Türkiye agreed to buy 20 Eurofighter Typhoons from the UK, a deal worth £8bn. In his first visit to Ankara, UK Prime Minister, Sir Keir Starmer inked the deal with Türkiye's President, Tayyip Erdogan, with the UK's MoD stating it as the "biggest fighter jet deal in a generation." Türkiye plans to purchase an additional 24 Typhoons from Oman and Qatar. The first of the new build jets are set to arrive in 2030. Meanwhile, on 17 November, Ukraine signed a Letter of Intent (LoI) to acquire up to 100 Dassault Rafale fighters from France. The LoI, announced by the Ukrainian President, Volodymyr Zelenskyy and French President, Emmanuel Macron, also includes other defence equipment.

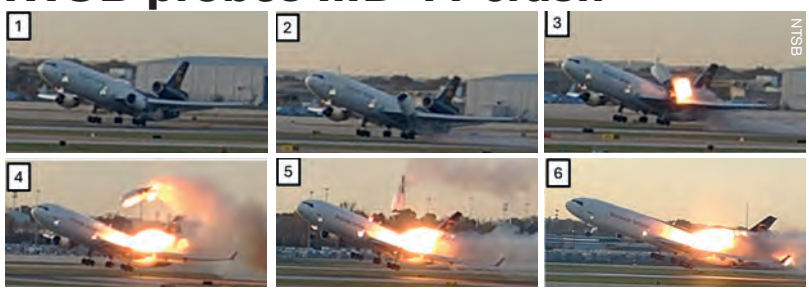
SPACEFLIGHT

China launches emergency capsule after debris risk

Three Chinese taikonauts who were 'stranded' on the Tiangong space station since 14 November, now have a return vehicle docked to the station. A Long March 2F/G rocket, carrying the uncrewed Shenzhou 22 spacecraft, launched from the Jiuquan Satellite Launch Center on 24 November to low Earth orbit toward the space station. The taikonauts, serving the Shenzhou 21 mission, arrived at the station on 31 October, but the spacecraft that delivered them took home the previous mission, after their own vehicle was deemed unsafe due to a piece of space debris causing a crack in one of the windows. Following docking, the taikonauts will complete their six-month mission, ahead of the arrival of Shenzhou 23, in April 2026.

AEROSPACE

NTSB probes MD-11 crash



NTSB

The loss of a UPS McDonnell Douglas MD-11 cargo aircraft at Louisville Airport on 4 November, which claimed the lives of all three crew aboard and at least 14 people on the ground, has resulted in an emergency FAA AD, grounding the type "until the airplane is inspected and all applicable corrective actions are performed." The two largest operators, UPS (26 airframes) and FedEx (28) had already voluntarily grounded the type. Images released by the US NSTB in a preliminary report show how the No1 engine and most of the pylon had detached on take-off.

Investment Corporation and a consortium of aerospace investors. The Brisbane-based company is developing the 10ft-long Dart single-use, 3D-printed, high-temperature alloy, green hydrogen-fuelled scramjet technology demonstrator. Flight testing will begin at NASA's Wallops Flight Facility, Virginia in January.

Following the C5+1 summit of Central Asian countries in Washington DC on 6 November, Boeing announced three orders from the region. Air Astana has agreed to purchase up to 15 Boeing 787 Dreamliners, Somon Air committed to ten 737 MAX 8 jets and up to four 787-9s while Uzbekistan Airways converted options from a previous agreement into a firm order for eight 787 Dreamliners.

China's People's Liberation Army Air Force (PLAAF) has published the first air-to-air video of the GJ-11 stealthy flying-wing UCAV that was first spotted in satellite imagery on the ground earlier this year. The PLAAF has also confirmed that the type's official name is now Fantasy Dragon, rather than continuing with the Sharp Sword name applied to prototype and pre-production aircraft.

Airbus, Thales and Leonardo signed an MoU on 23 October to merge their space activities into one company. The project, which is yet to be named, will employ around 25,000 people across Europe, and expects to have an annual turnover of about €6.5bn. According to the joint statement, Airbus will contribute with its space systems and space digital business, Leonardo will contribute with its space division, including its shares in Telespazio and Thales Alenia Space, with Thales contributing similarly. Airbus will have 35% ownership of the new company, with Leonardo and Thales owning 32.5%. If the MoU passes regulatory clearances, the new unified company will be operational in 2027.

The UK CAA has proposed a 4.7% rise in General Aviation charges for 2026/27 as part of its annual consultation on fees. The price hike will affect licensing, airworthiness, aircraft registration and oversight services for GA users.

Radome

AIR TRANSPORT

Hong Kong 747 runway excursion report released

The Hong Kong Air Accident Investigation Authority (AAIA) released its preliminary investigation into the Boeing 747 that suffered a runway excursion on 20 October, killing two ground staff. It found the aircraft experienced an "abnormal" acceleration after landing, according to sources speaking with the *South China Morning Post.* According to the report, the No4 engine accelerated to 90% fan speed. While the details of the incident included in the preliminary investigation are slim, the report claimed that, after landing when the aircraft was decelerating, an 'autobrakes' message appeared in the cockpit, after which the captain took over control from the co-pilot, leading to the runway excursion.

AEROSPACE

ZeroAvia gets onboard zero-emission Airlander

Hybrid Air Vehicles

British companies, ZeroAvia and Hybrid Air Vehicles have signed an MoU to collaborate on a hydrogen-electric variant of Airlander 10 airship. The variant will be powered by ZeroAvia's ZA600 600kW hydrogen-electric powertrain with hydrogen stored in the airship's large hull. As part of the agreement, the companies will also study the potential applicability of ZeroAvia's hydrogen-electric technology to future larger aircraft developed by Hybrid Air Vehicles, and assess planned Airlander 10 operations to define the hydrogen fuel infrastructure requirements.

GENERAL AVIATION

Cub Crafters

Carbon Cub reaches new heights

A factory-stock CubCrafters Carbon Cub UL climbed to 37,609ft over the California coast on 28 October, setting an unofficial new world altitude record for its class of aircraft. Although not an official FAI record attempt, the Rotax 916iS powered Carbon Cub UL surpassed the official FAI Ultralight category world record altitude of 35,062ft, which has been held by a Rutan Long EZ since 1996. Piloted by Jon Kotwicki, the Carbon Cub UL took 62 minutes to reach its peak altitude.

DEFENCE

RAF pushing to expand CCA trials in 2027

The RAF's Autonomous Collaborative Platform (ACP) strategy, which looks to 'aggressively' introduce such capabilities to the front line continues with plans being scoped to flight test a Collaborative Combat Aircraft (CCA) in 2027, according to RAF sources. Selection of the CCA is yet to be decided, but the aircraft would be a large 'non-attritable' combat drone, with the goal of bringing additional combat mass to the RAF. Ratios of CCA to piloted fighters remain flexible but initial plans are likely to be in the region of four CCAs to one crewed fighter, according to sources. The aim is to accelerate autonomous systems and long-range strike capability for the UK. Comparable UCAV CCAs currently being developed around the world include the Boeing MQ-28, Shield AI X-Bat, Helsing CA-1 and Anduril Fury.

NEWS IN BRIEF

The European Commission (EC) has unveiled its Sustainable Transport Investment Plan (STIP), which is designed to boost renewable and low-carbon fuels for aviation and waterborne transport. The plan is part of the EU Competitiveness Compass and the Clean Industrial Deal, which aims to create a common approach to boost investments into renewable and low-carbon fuels to meet targets set out in the ReFuelEU Aviation.

Ben Gurion Airport, Israel's main civil aviation hub, has been approved for a major expansion project. The project, valued at around $83m, will involve an upgrade of 7,000m² across four floors of Terminal 3 to add much needed capacity and improve passenger service, after fears that the airport would run out of capacity in just five years with 40 million passengers expected.

Following Ukraine's LoI to buy Saab's Gripen E fighter, the manufacturer's CEO, Micael Johansson told the *Financial Times* that it is "evaluating ways to rapidly increase output." With the order doubling the current production rate of Gripen Es, Johansson suggested new assembly lines could be established in Canada.

ON THE MOVE

Lt Col Alexander 'Knight' Prevendar takes over as Lead Pilot of the USAF Thunderbirds for the 2026-2027 seasons.

Tom Dunn MBE FRAeS, co-founder and Chairman of UK-based Aeros Flight Training is retiring with immediate effect. Current CEO, Nick Dunn, will run the company until a new chairman is announced.

QinetiQ Head of Flight Operations, Paul Shakespeare FRAeS, is to take over from Vertical Aerospace test pilot, Paul Stone, as Chief Pilot of the Shuttleworth Collection from the start of the 2026 airshow season.

Honeywell has named Jim Currier as the new President and CEO of its Aerospace division, ahead of a split into separate units in Q2 2026.

News Analysis

AIR TRANSPORT

Is domestic air travel in the UK on the critical list?

Bella Richards

Pictureguy20

Eastern Airlines collapsed in October with the majority of its 330 staff made redundant.

On 27 October, UK regional airline, Eastern Airways ceased operations followed shortly by the collapse of regional carrier, Blue Islands in mid-November. The latter half of 2025 has proven deadly for the regional airline industry of the UK, mixed with the recent history of several other carriers going bust, including Flybe in 2023 and Bmibaby in 2012. The closure of these companies is not just a coincidence, but reflects a larger trend of decreasing domestic flights across the UK, with new data revealing that regional flights have more than halved over the past 20 years.

The data

On 14 November, aviation analytics company, Cirium released new figures, showing that compared to the 454,375 flights scheduled in 2006, this year has seen only 213,025, reflecting a steady decline over the past two decades. Furthermore, 2025 will see almost 76,000 fewer flights compared to pre-pandemic levels. According to Cirium, this amounts to an average daily reduction of 661 flights across the UK.

This decrease in domestic travel does not all fall on the consumers' hands, with Cirium claiming that the number of available seats has dropped dramatically over the past two decades – showing a 35% decrease from 39.1m in 2006 to just 25.5m this year.

Cirium

UK domestic flights have halved in the past two decades, according to new data from Cirium.

The catalyst

Those who have watched UK travel with a keen eye may not be surprised by these statistics. When Blue Islands entered administration in November, the airline still owed the government of Jersey £9.1m in loans handed out during the Covid-19 pandemic. One of the more significant losses in the past decade was Flybe in 2023, which operated a fleet of over 60 de Havilland Canada Dash 8 and Embraer 175 aircraft and flew to almost 60 destinations across the UK, Ireland and Europe. Cirium says that the demise of Flybe caused one of the larger ripples through the troubled UK domestic airline industry, but that problems of economic viability for smaller airlines had started well before its closure in 2023 and before the major shock that was Covid.

The why

The cause of this decline has been blamed on several factors – the pandemic, the rise in Air Passenger Duty (APD) tax, environmental concerns and the surge in rail use. In February 2007, the UK government announced a doubling of passenger tax, seeing certain short-haul flights switch from £5 to £10, and long-haul from £40 to £80 in additonal costs on top of ticket prices. The move was part of the 2006 pre-budget report, with the government citing climate change as the largest motivator. Climate change has also been identified as a growing concern for consumers, who are opting for the greener option of rail where surface travel options are feasible. Indeed, rail has been cited as up to 13 times more sustainable than flying. According to the Office of Rail and Road, there has been a 50% increase in rail travel between 2005/6 to today. While consumers are choosing to use rail for their domestic travel, and still utilising flying for overseas trips, it puts carriers, such as Blue Islands, which served the Channel Islands, in a more vulnerable position because most of its non-seasonal routes were within the UK, which likely played a role in its eventual downfall.

While these figures provide a grim outlook on regional air travel in the UK, it is a clear indication that the nation travels differently now, passengers are arguably more carbon-emission conscious and the added burden of rising APD has had a disproportionate effect on smaller carriers which already struggle with the razor-thin profit margins.

By the Numbers

Understanding the world of Aerospace through data

Airline orders announced at the Dubai Airshow 2025

AIRBUS 232 ORDERS

Airbus A321neo 150

Flydubai: A321neo **(150)**

Airbus A350 66

Air Europa: A350-900 **(40)**

Etihad Airways: A350-1000/A350F **(10)**

Emirates: A350-900 **(8)**

Ethiopian Airlines: A350-900 **(6)**

Silk Way West: A350F **(2)**

Airbus A320 10

Buraq Air: A320neo **(10)**

Airbus A330 6

Etihad Airways: A330-900 **(6)**

BOEING 174 ORDERS

Boeing 737 94

Flydubai: 737 MAX **(75)**

Ethiopian Airlines: 737 MAX **(11)**

Air Senegal: 737 MAX **(8)**

Boeing 777 65

Emirates: 777X **(65)**

Boeing 787 15

Gulf Air: 787-9 **(15)**

Embraer

4 E175 for Air Côte d'Ivoire
3 E195-E2 for Helvetic Airways

Airbus, Boeing and Embraer

Pushing the Envelope

Exploring advances on the leading edge of aerospace

Robert Coppinger

UK firms testing 'computer refined' rocket alloys

The tremendous forces raging through a rocket engine's turbopumps, propellant feed lines, combustion chamber and nozzle originally needed the robust manufacturing processes of casting and forging. In the decades since the first launch vehicles, computer-aided design, computer-controlled production and advances in materials science have led to more powerful engines and more efficient levels of thrust. Additive manufacturing was applied to improve rocket performance more than a decade ago with 3D-printed elements used alongside conventionally made parts.

Computer made

Two UK firms are now co-operating on a project to test a computer refined alloy. It could, potentially, be used for nozzles and combustion chambers, and one of the two project partners is developing its own rocket. Rotherham company, Metalysis produces metallic and intermetallic powders and alloys. It will produce the computer refined refractory alloy powder, Tanbium, which is a combination of the elements tantalum and niobium. The two elements have been used for launchers for decades and are refractory, which means they have high temperature properties, necessary for rocket engines. Some of the well-known aerospace refractory alloys are made from molybdenum, tungsten and chromium, one example being the alloy, Inconel, which is made of nickel and chromium.

It is hoped that Tanbium can overcome the limitations of legacy alloys and their supply challenges. Legacy alloys traditionally have several limitations, such as rocket engine burn time, oxidation resistance, reusability and weight, while Tanbium is expected to extend component lifetime, reduce its weight and have no negative impact on performance.

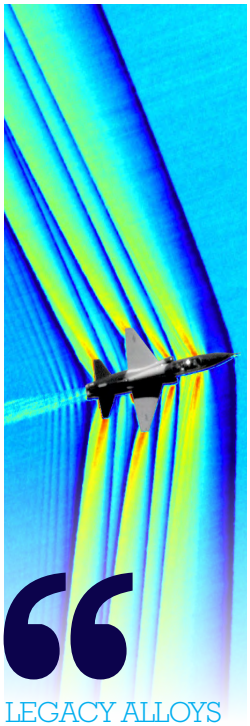
Metalysis' Managing Director and Chief Scientist, Dr Ian Mellor, explained that the nine-month project was to show the material can perform as predicted. He pointed out that most powders that have been used in additive manufacturing are long-standing materials that were not designed for 3D printing, and this is a key difference with Tanbium. The first five months were to see the Swedish project participant, Thermo-Calc Solutions, use what it calls its 'integrated computational materials engineering' to make final adjustments to Tanbium's composition and, by January 2026, Metalysis will produce the powder. The company was created to exploit the Fray Farthing Chen (FFC) Cambridge Process invented in 1997 by University of Cambridge Materials Science and Metallurgy Department researchers, Derek Fray, Tom Farthing and George Chen. The process was created to use electrolysis to extract titanium and, according to Metalysis, it allows metals with very different chemical and physical properties to be combined.

"One of the reasons why we were chosen as the partner to make the metal powder is that we can combine elements in alloys, which are very challenging or impossible using conventional metallurgy," said Mellor. In the years since its invention, 49 elements of the periodic table have had the FFC Cambridge Process applied to them. Metalysis' FFC electrolysis produces what the firm calls a metal sponge, which is then put through crushing and milling processes and is finally washed and dried for the final metal powder. Mellor explained that his company could pinpoint the size of the particles produced to ensure there was less waste in the process.

Putting the alloys to the test

While Metalysis is not 3D printing Tanbium, its project partner, Glaswegian launch vehicle developer, Skyrora, is. Skyrora, which also has Edinburgh offices uses 3D printing for its Skylark sounding rockets and Skyrora XL rocket and its printer, called Skyprint 2, was custom-built to produce parts up to 2.3m across. Skyprint 2 uses a directed energy deposition process that fuses powder particles, melting them with thermal energy, as the powder is deposited. This leaves a near net shape which would require only machining to finish.

Skyrora has previously stated that Skyprint 2 has been used with Inconel to provide parts for the firm's rocket engines. The project with Metalysis, which is European Space Agency funded, will help add Tanbium to Skyprint 2's range of materials. According to Skyrora, Europe is dependent on the US for an aerospace alloy, C103, which is made of niobium, hafnium and titanium, and Tanbium could help relieve that dependency. The expectation is that Skyrora will print Tanbium test pieces using Skyprint 2 from around April, just five months into the project.



> LEGACY ALLOYS TRADITIONALLY HAVE SEVERAL LIMITATIONS, SUCH AS ROCKET ENGINE BURN TIME, OXIDATION RESISTANCE, REUSABILITY AND WEIGHT, WHILE TANBIUM IS EXPECTED TO EXTEND COMPONENT LIFETIME, REDUCE ITS WEIGHT AND HAVE NO NEGATIVE IMPACT ON PERFORMANCE

Transmission

LETTERS

Another black aviation hero to remember

I enjoyed reading Kasha-Marie Ababio's 'Black History Month – Five notable black aviation heroes' blog.[1] Another black aviation hero that I had the privilege to meet is Maj Gen Charlie Bolden. He was a former USMC pilot who became an astronaut and commanded the Shuttle mission that launched the Hubble telescope into space. President Obama later appointed him NASA Administrator and he gave the keynote speech at the RAeS in 2014, when I was President.

Air Cdre Bill Tyack FRAeS

Call for more UK-centric inspiration

The recent RAeS Black History Month communication highlighted five examples to inspire/encourage potential recruits to the industry. I read it with interest, hoping to forward it on to my four mixed-race grandchildren as an encouragement to consider a career in our industry. However, I chose not to as four of the five examples were US based.

I recognise that the RAeS has a global reach and an international membership. Nevertheless, I was disappointed that the examples were skewed towards the US. It is good that the individuals highlighted what they did, but disappointing that there were not some more obvious examples from UK or Commonwealth countries.

I do not write to complain, more to seek to encourage a wider range of examples – with a genuine desire to engage my Sheffield-based school-aged grandchildren in our wonderful aerospace industry.

Dr Gareth Williams FRAeS

Calling all Chipmunk owners, pilots and enthusiasts

S Bridgewater/RAeS

On Friday 22 May 2026, the de Havilland Chipmunk Appreciation Society will be celebrating the 80th anniversary of the first flight of the Chipmunk, which occurred that very day in 1946.

To mark the milestone, we aim to gather as many Chipmunks as possible at Wolverhampton Halfpenny Green aerodrome (EGBO) for the enjoyment of all. I have invited 87 Chipmunk owners so far – and more will be added whenever I receive their email addresses. If you have not yet received an invitation, and would like to fly in to the event, please PPR directly with EGBO and/or follow the de Havilland Chipmunk Appreciation Society on Facebook[2].

The event will be open to all, whether they fly or drive in, and will be of interest to anyone who has ever flown, owned, operated, engineered, modelled or dreamed of Chipmunks.

Carol de Solla Atkin

Would you board an AI-piloted airliner or fight a war?

It occurs to me that Dr Rashid Ali's recent blog 'Would you board an AI-piloted airliner?'[3] and Sophie Somerville Roberts' blog 'Recruiting a next-generation air force – will Gen Z fight in WW3?'[4] share a similar message. The latter refers to the need for "peer-to-peer social reinforcement for those considering enlistment" while the former refers to the need for "airlines and aviation authorities to make public trust a priority."

So much of our industry is built on hype and false promises – so surely the takeaway here is the need for honesty.

John Young

Breaking the ceiling

@derekts1/Instagram

Response to 'China Airlines' all-male crew highlights ongoing gender inequality in Asian and Middle Eastern aviation.'

Lauren Wilson This is fantastic. I have been talking about the rarity of all male crews for years now. My company did a post with a social media post about an all male crew recently, which I was delighted to see, but it gained very little attention sadly. That probably tells a story in and of itself.

BWB bizjet breaks cover

S Bridgewater/RAeS

Response to 'RAeS interviews Kingdom Aircraft Manufacturing, at Dubai Airshow to discuss its blended-wing business jet concept.'[5]

Matt Willis I guess the beauty of a BWB bizjet is that you do not get the concerns usually raised at airliner scale – notably that hardly anyone has a window seat, and the outermost passengers are so far from the axis that they may get airsick from the motion (I do not believe the latter will be a problem but time will tell).

Game for a flight

Game Composites

Response to 'Emirates Flight Training Academy uses Gamebird GB1 for UPRT training.'[6]

Basel Hammond I love those curved leading edges. I had a chance to fly the one based at Booker and it flies every bit as good as it looks. There is an option to have a single-seat canopy which looks even sleeker! They got so much out of that design; to think it has a 1,000 mile range and is still an unlimited aerobatic ship (albeit not with all that fuel in it).

Nigel Hitchman Everyone I know who has flown one says they are great. A couple of friends in the US just ordered them, they were very impressed, even though they also have P-51s and Corsairs to fly, among other things.

A true pioneer

British Airways

Response to 'On this day in aviation history, on 31 October 1987, British Airways accepts the airline's first female pilot, Lynn Barton.'

Ian Haskell I remember Lynn as a flying instructor at Southampton when I worked in the tower in the early '80s before she joined AirUK.

Brian Smidmore All because little airlines, like DanAir, gave ladies a chance.

James Martin I remember reading an in-flight magazine on Airtours in 1997 and they interviewed "one of just four" female pilots for a feature.

Richard J Bartlett-May I met Lynn when I worked for CabAir in 1977. Lynn was working at the London School of Flying/CabAir. She was always a very pleasant and confident person.

Russia's return?

Response to 'Russia has been invited to the Dubai Airshow, with Su-57 and Ka-52 both flying.'(7)

Terry Holloway Given the sanctions against them, they should not be there. Any reporting only serves to promote Russian interests on the world stage.

Charles Alcock Maybe what we all should have been asking this week is why was Russia brought back into the airshow fold?

Fighter or eVTOL pilot?

Response to "Great chat with Joby Test Pilot, Peter 'Wizzer' Wilson, who says the S4's ease of flight would make F-35B pilots right at home due to FBW unified controls.'

@the_engi_nerd I worked the F-35B ski jump take-offs. Wizzer was the pilot, and also the only pilot I ever saw stand up to the madness of the way the test engineers wanted to schedule things. "I don't want to brief at 6.30am for a 10am walk and 10.30am take-off. I want to take my kids to school. If it is a 10am walk, I am briefing no earlier than 9am and you had better not have engineers show up at 6am and then need a waiver for when we inevitably slide to 2pm".

Immitation is flattery?

Response to 'Is anyone else getting Heinkel He162 vibes from this? [EDGE Sinyar LAR3P at Dubai Airshow]'.

@MikePiesing There was a Ukraine missile that had V-1 vibes. Is this a trend?

@FennellJW The He162 was a good, low-cost solution for a cheap, easy-to-produce jet. I expect we will see more of this confirguration.

@AhamadNooh The configuration reminds me of the Flaris LAR 1 VLJ.

Flying quarterbacks

Response to 'Boeing Dubai brief on F-15EX and MQ-28 Ghost Bat. Officials point out capability of two-seat Eagle to command CCAs as a 'quarterback' to the air battle.'

@metoyou99919097 Is the CCA a radar sink for the F-15 radar source? How effective is that against stealth air to air?

@DiscussDefence Interesting on the two-seater tasking. I have wondered how Tempest would do similar with only one on board; surely it is too much for a single crew to manage?

DARTing to Dubai

Response to 'Zhongke TA-20 – based on the Diamond DART 450 – debuts at Dubai after delayed flight from China. We speak exclusively to TA-20 test pilot, Giancarlo 'Magoo' Maragucci.'(8)

@JetSetGomez The TA-20 is exactly what motivates me to keep following the scene: cutting-edge training technology and a potential boost to the UAE's aerospace sector.

The howling Hongdu

Response to 'Star of the show? The 'howling Hondgu' L-15 of the UAEAF's Fursan El Emirati display team. Incredible flying display with an unmistakable Hawker Hunter-like 'blue note' sound.'

@FaySue6 Can we confirm which type of jet engine the UAE's L-15 uses? Some sources claim it is the Chinese WS-17, but some claim it is an indigenously developed jet engine called the WS-12 Minshan. Designed to replace the Russian-designed AI-222-25, the Minshan is a low-bypass afterburning turbofan engine with an estimated maximum afterburner thrust of 5 tonnes.

(1) aerosociety.com/news/black-history-month-five-notable-black-aviation-heroes/
(2) facebook.com/groups/dhchipmunk
(3) aerosociety.com/news/would-you-board-an-ai-piloted-airliner/
(4) aerosociety.com/news/recruiting-a-next-generation-air-force-will-gen-z-fight-in-ww3/
(5) youtu.be/JRsXj4s_F4Q?si=aHJlec4mJ85rzSDy
(6) linkedin.com/feed/update/urn:li:activity:7395939980344233984
(7) linkedin.com/posts/royal-aeronautical-society_on-display-at-the-dubai-airshow-2025
(8) youtu.be/lDq4daZq34M?si=E6s0zCZcTocX-lMo

Would **you** like to help guide the Society?

The Society would like to hear from members who are interested in standing for Council in the 2026 elections. The Council represents all the aerospace sectors and provides critical input to the Board of Trustees. To fully represent these sectors, we need candidates from across the industry, whether you're a newly qualified apprentice or a senior engineer, a pilot or a flight operations controller, an astronaut or a mission specialist, a leader in our industries, a consultant or any of the myriad of professionals who support us. We need your skills to enhance our Council.

To become our President, you need to be elected from the Council by the Council. Our President chairs Council meetings and also serves on the Trustee Board. The President represents the Society at exciting events around the world, visits as many branches, divisions and corporate partners as possible, and uses their experience, knowledge and skills to improve the influence and standing of the Society. The monthly message from the President describes some of the range of activities and initiatives that they do on behalf of the Society.

If you are able to donate your time and expertise you will gain the opportunity to take part in interesting debates on issues affecting our sectors and the Society. You will work with other enthusiastic and committed professionals to help shape our future direction and it's a great opportunity for professional development and to enhance your CV. If you wish to, you will also have the opportunity to get further involved in other roles at the Society.

If you are interested, require further information or wish to apply please visit: **mi-nomination.com/raes2026**

Please note that all nominations must be submitted no later than 31 January 2026 at 23.59 GMT.

Stephen Bridgewater/RAeS

Dubai soars in the sun

TIM ROBINSON FRAeS and **STEPHEN BRIDGEWATER** FRAeS report on some of the most exciting news and highlights of the Dubai Airshow 2025.

Taking place between 17-21 November, at Al Maktoum Airport, (Dubai World Central) this year's Dubai Airshow was one of the biggest yet, with 248,788 visitors for the week-long show. It featured over 1,500 exhibitors from 115 countries and more than 450 speakers in the conferences running alongside the exhibtion. The static and flying display featured over 218 aircraft with highlights including the UAE Air Force Fursan Al Emarat team, Russian Knights, IAF's Surya Kiran, as well as the first appearances of the Joby S4 eVTOL, Sukhoi Su-57 and COMAC C919 in the skies. The flying display also saw a unique parade of airliners celebrating home airline, Emirates' 40th anniversary, as well as a night-time drone light show. Sadly, the last day of the airshow ended on a tragic note when a HAL Tejas fighter from the Indian Air Force, crashed during its display, killing its pilot, Wg Cdr Namansh Syal.

By the end of the week, the show had concluded with around 518 commercial aircraft orders and commitments, with the bulk (406) split between Airbus (232) and Boeing (174) with Gulf-based airlines accounting for the biggest totals – and the total value of deals (including military and support contracts) was around $202bn.

Let's take a look at some of the highlights.

Emirates places vote of confidence in delayed 777X

Kicking off the week in style for its 40th birthday and the biggest deal in terms of value ($38bn) was Emirates which announced an order for 65 Boeing 777-9s, despite the long-delayed widebody now being slipped to spring 2027. The massive buying power of Emirates also saw the reveal that the carrier would be taking part in a feasibility study for a stretched 777-10 version – bringing seating up to around 470 passengers.

While Emirates decided to let Airbus wait over a rumoured A350-1000 commitment, it did provide a consolation prize in the form of a signing for eight A350-900s worth $3.4bn.

'Howling Hongdu' wows crowds

Wowing visitors at the show with an incredible entrance, stunning display and unique 'whistling' noise was the UAE Air Force's Fursan Al Emarat team (The Knights) flying its new jet – the Chinese-made twin-engine, twin-seat Hongdu L-15 advanced trainer. Previously flying the Aermacchi MB-339, the first pair of L-15s were delivered in late 2023, with the team training in secret to convert to the new aircraft for the show. First flown in 2006, the Hongdu L-15 was developed in co-operation with Yakovlev and is an advanced trainer and lead-in-fighter trainer now fielded by China' s PLAAF.

Boeing combat drone to make live air-to-air missile test

In a pre-show media roundtable ahead of the show, Boeing Defense executives provided an update on the company's strategic focus in the Middle East, key programmes and milestones, with the defence division still riding high after winning the "transformational" NGAD contract from the USAF with its F-47. Calling the NGAD win "humbling", BDS CEO, Steve Parker said: "the investment goes back over a long period of time, going back a decade in materials and technologies and advanced manufacturing, and engineering." While Parker was coy about the status of the highly-classified F-47, which the USAF has said is now in production, he did reveal that Boeing's MQ-28 Ghost Bat UCAV, developed in co-operation with the Royal Australian Air Force, will make a live AIM-120 missile shot against a drone target in Australia this month in a "tactically relevant scenario." Said Parker of the MQ-28: "I think it is the most state-of-the-art advanced CCA in the world today."

Emirates

Dubai Airshow

Teaming up to beat the space tech 'valley of death'

Announced at the show was 'Space for Earth Labs' – an MoU between Mohammed Bin Rashid Space Centre (MBRSC) and DIFC's Innovation Hub to help small space start-ups transfer their R&D and bright ideas to commercial products. The initiative is being supported by RELM Insurance, with the goal of a "fully integrated ecosystem – providing end-to-end support from venture licensing and co-working to curated start-up programmes." The first project will be a geospatial accelerator, with the partners inviting start-up proposals for Earth Observation (EO) and AI-driven solutions to tackle climate resilience and environmental monitoring.

Seaglider skims in

Over at the UAE's Strategic Development Fund (SDF) pavilion was a full-size mock-up of Regent's Vicerory Seaglider wing-in-ground (WIG) effect vehicle. Technically, a maritime vessel rather than an aircraft, the12-passenger all-electric vehicle features large windows and a spacious ceiling. With the prototype already flying in the US, the manufacturer is aiming the Seaglider at both military and civil roles, with the UAE and its neighbours a particulary attractive market for connectivity and tourism. A Seaglider ferry could connect Dubai and Abu Dhabi in just 30mins, Regent CEO, Billy Thalheimer told *AEROSPACE,* compared to a road trip of an hour and a half.

Emirates selects Starlink

On display at the show was a Boeing 777 from Emirates – the first in its fleet to be equipped with SpaceX's Starlink high-speed satellite connectivity – with the airline saying 15,000 visitors had tried it at the show. The airline plans to install Starlink on its entire 232 aircraft fleet over the next two years.

Airbus racks up A350 sales

Airbus announced on the eve of the airshow that Air China Cargo had signed a purchase agreement for six Airbus A350F aircraft, becoming the first customer to order the all-new A350F on the Chinese mainland. The OEM also won an MoU from Spanish airline, Air Europa for 40 A350-900s worth around $17bn, while Silk Way West signed for two A350Fs. Another A350 order came from Ethiopian Airlines which signed for six.

Tim Robinson/RAeS

Omen of the future

On the eve of the show, US AI defence start-up, Anduril revealed it had partnered with UAE military technology and drone group, EDGE to co-develop the Omen – a hybrid-electric tailsitter UAV bringing an extended range. By using the tailsitter configuration, which uses the same engines for vertical lift as horizontal cruise, it means that weight and complexity is reduced – increasing endurance and range – up to three-to-four times that of comparable Class 3 UAVs.

Stephen Bridgewater/RAeS

'Not hearing is believing' as Joby eVTOL flies in display

As Joby Aviation continues testing its S4 eVTOL in Dubai ahead of potential certification and entry into service in the UAE as early as 2026, it is fitting the aircraft became the first advanced air mobility vehicle to take part in a Dubai Airshow. The almost silent S4 performed a relatively energetic display routine, including tight turns in wingborne flight and several transitions from the hover and back. Talking to *AEROSPACE,* former Harrier and F-35B test pilot, Pete 'Wizzer' Wilson, who was displaying the S4, noted how easy it would be for a F-35B pilot to pick up – thanks to its 'unified control' VTOL FBW laws. Bank angle, he said, is limited to 60° by the FBW, returning to 30° if stick pressure is released, while pitch limits will be +/-12°. Missing from the flying display, however, was rival Midnight eVTOL from Archer, which is also aiming to begin services in the UAE in 2026.

While it did not have an airliner at this year's Dubai Airshow, Saudi Arabian start-up airline, Riyadh Air signed a strategic MoU with Saudi's The Helicopter Company to provide VIP passenger shuttle services in the Kingdom – with a specially marked Airbus H160 in the static display.

All images Tim Robinson/ Stephen Bridgewater unless otherwise credited.

Tim Robinson/RAeS

Having developed a successful VLJ in the form of the HondaJet after an earlier air taxi boom of the early 2000s, at the show Honda unveiled its cabin concept for a hybrid-electric VTOL aircraft. The company has already flown the design in a subscale configuration, but is taking the long view with AAM saying that "the 2030s will be the best time period for eVTOLs" due to the lack of infrastructure currently available. Using a hybrid-electric propulsion, leveraging Honda's Formula 1 experience, the four passenger lift+cruise eVTOL would have a range of 400km.

Emirates and Safran Seats announced an MoU to build Dubai's first seat manufacturing facility. It will initially build Business and Economy Class retrofit seats for Emirates and other carriers before expanding to line production seats.

Flydubai hedges its bets

A surprise deal at the show was previously all-Boeing low-cost carrier, Flydubai which anounced an MoU worth $24bn for 150 Airbus A321neos to support its growth and shift to DWC airport — with first deliveries to begin in 2031. However, the airline also reaffirmed its commitment to Boeing with a $13bn order for 75 737 MAXs (and options for a further 75).

Air ambulance operator links with local hospital

Business aviation operator, FAI Aviation Services announced that, in a first-of-a-kind agreement in the region, its Air Ambulance division had signed a partnering agreement with Medcare Royal Speciality Hospital, Dubai. This will integrate local ICU medical teams into FAI's Air Ambulance missions, strengthening aeromedical services across the region.

Dubai becomes world's busiest airport

Just in time to mark the success at the UAE's largest aviation trade show, Dubai International Airport (DXB) has taken over the title of the world's busiest airport from Hartsfield-Jackson Atlanta International Airport (ATL). As of November 2025, DXB offered an impressive 5.29m available seats, surpassing Atlanta's 5.12m seats by 2%. This milestone is even more impressive as the airport operates no domestic flights. The achievement is a recognition for Dubai's investment in infrastructure, technology and the overall passenger experience over the past decade.

Space co-operation on the agenda

Over at the conference track, one of the topics for discussion was international partnerships in outer space. As Chris White-Horne, Deputy CEO of the UK Space Agency noted, "Which side of the road will we drive on on the Moon?" – a seemingly trivial sci-fi question but one that highlights the needs for international common standards (eg docking ports) to be agreed sooner rather than later. He concluded: "we need diversity of ideas, and that comes from international collaboration."

L3Harris to pitch MPA bizjet to UAE

Over at L3Harris, the company briefed selected reporters on how it was using its extensive knowledge and experience in developing and integrating spyplanes for US and international customers, which include the RC-135 Rivet Joint, EC-37B Compass Call and MC-55A Peregrine for the RAAF to potentially pitch a multi-mission bizjet, based on the Bombardier 6000/6500 to the UAE Air Force for the maritime patrol/surveillance role.

Stephen Bridgewater/RAeS

Felon out on parole

The show also saw a major presence by the Russian aerospace industry, with the Sukhoi Su-57 'Felon' appearing in the same flying display as a USAF F-35 – only the second time that these two fighters have attended the same show. As well as the Ka-52 attack helicopter and Yak-130M advanced trainer – now given extra combat capability through an AESA radar – the Russian exhibit also featured a fifth-generation aircraft engine and models of the Su-57E with canted 2D thrust-vectoring nozzles, as well as an uncrewed version of the Su-75 'Checkmate' stealth fighter that was revealed four years ago at the 2021 Dubai Airshow.

RAeS President forges global links

Tim Robinson/RAeS

Attending the airshow was RAeS President, Alisdair Wood FRAeS, who used the opportunity to catch up with existing and potential Members, Fellows and Corporate Partners. His activities included attending forums, a visit to Emirates operations centre, the prestigious Gala Dinner, ADS Reception, Women in Aviation forum, delivering the RAeS UAE Branch Sir Maurice Flanagan Lecture, as well as meeting Emirates President, Sir Tim Clark FRAeS, where the conversation ranged from eVTOLs to AI and Sir Maurice Flanagan's creative writing.

Etihad signs deals with Airbus

More widebody orders were forthcoming from Abu Dhabi's home airline, Etihad, which signed an approximately $32bn deal with Airbus for 15 A330-900neos, seven A350-1000s and ten A350Fs — as well as a commitment to lease nine A330s from lessor Avolon.

Skyports to bring vertiports to Abu Dhabi

Ahead of the show, there was news from AAM vertiport developer, Skyports, which announced it had partnered with Abu Dhabi to develop a commercial vertiport network. Construction of the first two vertiports is already under way at Zayed International Airport and Al Bateen Executive Airport, with completion expected in early 2026. Ten vertiports are planned to be developed across the Emirate, as commercial eVTOL air taxis gear up to begin operations in the UAE in 2026.

GTF issues now behind it, says Embraer

Over at Embraer, the company provided a briefing of key trends shaping the small narrowbody market for its E-jets and also provided a ray of hope that the well reported issues with Pratt & Whitney GTF engines were now in the rearview mirror for the E2-series. Describing the second half of 2025 as a "turning point," Embraer Commercial Aviation CEO, Arjan Meijer said that engine supplier, P&W had invested additional capacity into its MRO and shop facilities — eliminating AOG events. Embraer's E2 twin-jets have also avoided the bulk of GTF issues that have plagued other types, notably the A320neo and A220, due to its PW1900G being the last GTF that was developed and the E2 being lighter than competitors.

Action Aviation taps into OneWeb

While Starlink has become ubiquitous for LEO broadband satellite, for some government and VIP customers wanting guaranteed high-speed connectivity, its popularity can be a drawback — especially over cities where ground users are present. Business aviation sales and management firm, Action Aviation announced at the show it would be equipping its 737 BBJ with Gogo's Galileo FDX terminal – which uses the rival Eutelsat OneWeb satellite megaconstellation. This currently provides almost maximum published speeds, says GoGo.

'Mental health' biggest challenge for long duration human spaceflight

With humans expected to make longer voyages into space in the coming decades, the UAE is positioning itself to be at the forefront of research into the human factors, pyschological and physiological effects of long duration space flights by building its own analogue astronaut facility to replicate missions to the Moon, Mars and beyond. Emirati analogue astronauts and researchers have already taken part in analogue ground-based missions with Russia, NASA and Germany's DLR, with this new facility developed with the Dubai Health Centre forming part of the UAE's ambitious 2117 Mars Project to establish a human settlement on Mars. The biggest challenge, said Shaikha Al Falasi, Science Lead, Analog Programme, Mohammed Bin Rashid Space Centre (MBRSC) was "mental health." Early studies, she said, had revealed that the most effective astronauts were those who practised mindfulness and meditation.

Among the many debutantes at the event was the Aurora BWB business jet, exhibited in model form by Colorado-based Kingdom Aircraft Manufacturing. Designer, Robert L Martin, told *AEROSPACE* that the concept was aimed at owner/pilot operators with operating costs similar to a King Air turboprop. Listen to Martin describing the project by scanning the QR code.

UK to invest $2.5bn into DWC

The show saw a major UK-UAE inward investment deal announced with Trade Minister, Sir Chris Bryant MP flying in to sign a $3.5bn Expression of Interest from the UK Export Finance credit agency into Al Maktoum International Airport Dubai World Central (DWC). This makes the UK the first and biggest foreign investor into DWC, reflecting growing UK-UAE ties.

Tim Robinson/RAeS

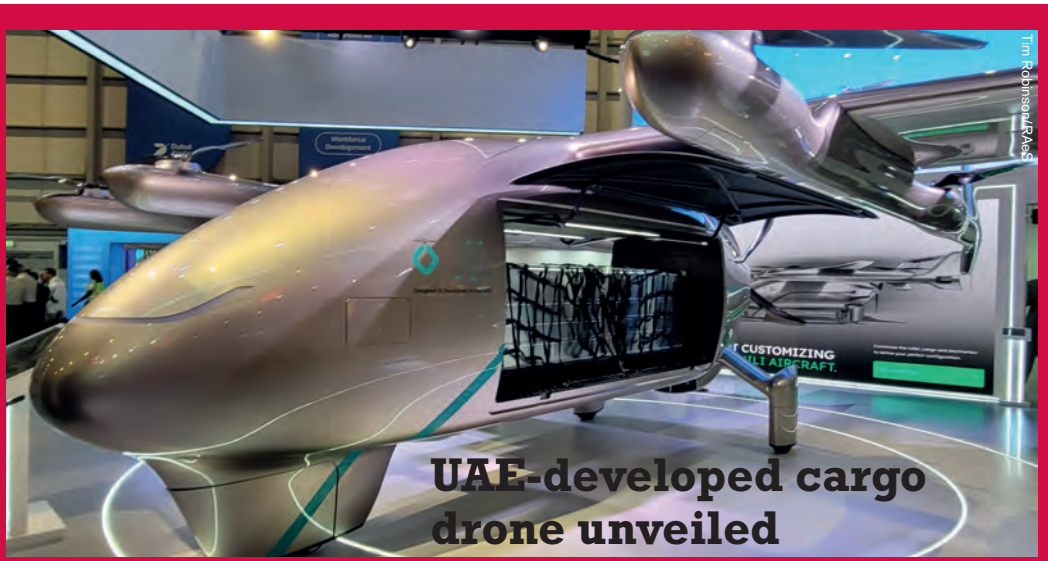
Cranfield Aerospace Solutions

The UK's Cranfield Aerospace Solutions unveiled a new hydrogen fuel-cell-powered UAV. The 18ft-span ST-5 Stingray is designed for surveillance, cargo and SAR missions. It has a BWB fuselage and wing with a twin boom tail and CAeS has signed an MoU with an unnamed maritime surveillance company for first deliveries in 2027.

COMAC C919 flies in

Spearheading a sales push from around 50 Chinese companies, which included OEMs, engine suppliers, drones and eVTOLs at the show was COMAC's C919 which took part in the flying display, with another example from China Southern Airlines on the static line. COMAC also brought its C909 twinjet in CBJ business aviation configuration.

Stephen Bridgewater/RAeS



Tim Robinson/RAeS

UAE-developed cargo drone unveiled

On the eve of the show, Abu Dhabi-based company, LODD, conducted the first flight of its Hili hybrid electric autonomous cargo drone. The aircraft, a mock-up of which was on display in the show's dedicated advanced air mobility hall, performed its first hover at Emirates Falcon Aviation in Al Ain on 13 November. The Hili is designed to transport a 250kg payload over a range of almost 700km, using a hybrid propulsion system that combines electric and internal combustion engines. LODD announced at the show that it had entered agreements with ST Engineering Commercial Aerospace, Skyports Drone Services and Emirates SkyCargo to explore cargo drone operations.

Regional airliner sales

As well as multi-billion dollar sales for both Airbus and Boeing, the 2025 show also saw smaller manufacturers scoop up deals. Embraer, for example, secured a firm order for four E175-E1s for Air Côte d'Ivoire, while Helvetic Airways signed for three E195-E2s. ATR, meanwhile, saw Ethiopian Airlines sign an agreement to lease two ATR 72-600s to be operated by Air Congo to support domestic connectivity in the Democratic Republic of the Congo. Finally, Indian regional airline, IndiaOne Air signed a LoI to acquire up to ten de Havilland Canada Twin Otter Series 300-G aircraft.

Skyscraper firefighting helos on display

First unveiled at this year's IDEX exhibition in Abu Dhabi, the unusually adapted UH-60L Black Hawk of the UAE's Joint Aviation Command is fitted with a Sky Cannon system produced by Canada's Dart Aerospace. Certified by the US FAA in 2021, the technology is now being trialled in the UAE, which is famed for its high-rise buildings and densely populated cities. Sky Cannon consists of a 7.6 metres-long extinguishing boom that can project water jets up to 40m into a burning building. The UH-60Ls modified to carry the system have had their stub wings removed and the cabin fitted with a 3,220l water tank and 190l foam tank. The helicopters are also fitted with an infrared camera and a rangefinder and a suction pump can refill the water tank from a lake or body of water in under 45 seconds. Also at the show and now boasting a high-pressure water lance for urban firefighting was the Kamov Ka-32A11M from Russian Helicopters. Once the go-to firefighting helicopter for many nations, the Ka-32 has suffered from the sanctions employed against Russia for its invasion of Ukraine and the company is now focusing on the home market and 'friendly' nations. Another high-rise firefighting aircraft on display was the EHang 216F eVTOL.

Ukrainian Vampire comes out in the daylight

At the show, Ukrainian drone manufacturer, Skyfall was showing off its Vampire UAV. The six-motor 'hexacopter' has been responsible for around 2/3 of all drone missions against Russia since it entered service in 2023. It flies mostly at night using thermal sensors and at around 1,500ft. "Tens of thousands" are in use, according to the company.

Autocraft E20+ eVTOL debuts

China's Autocraft and TCab Tech teamed up with Abu Dhabi's government-owned K2 to create the

E20+ eVTOL. The mock-up debuted at Dubai with the prototype expected to fly in Q1 2026. It is specifically created for the harsh Gulf environment with features to help it withstand heat, humidity and sand.

Gama to open new $65m bizav facility at Sharjah

With the planned shift of corporate jet operations to the DWC (Dubai World Central) from the already congested Dubai International, business aviation company, Gama Aviation is expanding its presence at Sharjah (SHJ) with a new $65m Business Aviation Centre. Set to be formally opened in January 2026, the new facility will include a 12,000m^2 hangar, passenger and crew facilities and dedicated ramp area.

Gulf Air signs for more 787s

Another Gulf airline making news at the show was Bahrain's flag carrier, Gulf Air which signed a firm order for 15 Boeing 787 Dreamliners and options for three more, finalising a previously announced MoU to support fleet expansion and growth. In more narrowbody sales, Boeing secured orders from Ethiopian Airlines for 11 737 MAX 8s and Air Senegal for nine 737 MAX 8s.

Jekta looks to seaplane opportunities in the region

At the show, Swiss-based Jekta signed a letter of intent with UAE-based Tahseen Aviation Services to explore how its PHA-ZE 100 electric amphibian could bring seaplanes back to the 21st Century in the Gulf region. Speaking with *AEROSPACE,* George Alafinov, CEO of Jekta, noted how the PHA-ZE was not just zero-emission, but its distributed propulsion allowed extreme STOL capability, enabling it to take off and land in small lakes and rivers. Using 10 propellers, the aircraft can also spin 360° on the water and also back up to a jetty, making this amphibian highly versatile.

Summary

Bringing together East and West along with friends, rivals and even enemies, the Dubai Airshow is unique in featuring aircraft and companies from around the world — with China's presence proving especially strong this year. While airlines continued to invest in future demand, there was also excitement about the future of Advanced Air Mobility that the UAE is set to pioneer. Finally, the high-level green light for Saudi Arabia to purchase US F-35s could very well open a whole new dynamic in the coming years.

Turboprops battle it out

The show saw the first appearance of two light turboprops - with China's Zhongke Aircraft T-20 prototype (left) appearing in the static. Based on the Diamond DART 450, developed a decade ago in Austria, the T-20 retains the general appearance of its forebear but has an anhedral tail, prominent winglets and a mix of Chinese and Western avionics. Planned to be built in the UAE in partnership with EDGE, the T-20 will be produced for basic and advanced training, as well as ISR roles. For an exclusive video interview with T-20 test pilot, Giancarlo 'Magoo' Maragucci, scan the QR code.

Meanwhile, UAE defence and aerospace group, Calidus used the show to unveil a light attack variant of its Bader 250 turboprop (right), which only made its first flight on 2 November. The aircraft features an all-composite construction and is the first aircraft to go through the UAE's Military Aviation Authority (MAA). Three prototypes are being built, with certification expected in 2027. The test programme is also blazing a trail for women in aviation in the region with the UAE's youngest female flight test engineer, Maitha Alkaabi.

Emirates Game for UPRT training

Dubai-based Emirates Flight Training Academy (EFTA) is exhibiting one of a pair of Gamebird GB1 aircraft at the show. Used by EFTA to provide upset prevention and recovery training (UPRT) to cadet pilots, all graduates of the scheme benefit from five hours training in the GB1. With 30 Cirrus, Phenom and Diamond aircraft in its fleet, EFTA is now training cadets on four distinct aircraft types before they graduate from the academy.

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Watch a wrap-up NOTAM news podcast from the *AEROSPACE* team with special guest, RAeS President Alisdair Wood.

AEROSPACE Video producer/ editor, Saurav Roy Chowdhury.

Winning the fight with

The war in Ukraine has taught us many lessons, especially that the West must continue to maintain an advantage in all warfighting innovations. Dr **DAVE SLOGGETT** reports on the rising need to have information superiority over adversaries to win a war.

History is replete with military axioms. One of the most durable states that for every measure there is a countermeasure. Commentators often invoke an aspect of Newtonian physics to suggest that this has parallels in Newton's Third Law – for every reaction there is an equal and opposite reaction. Evidence of the continuance of this axiom is found in the current war in Ukraine. However, several differences are emerging. The first of these is the speed of innovation. This makes what was once a slow and sometimes turgid measure-countermeasure cycle (measured every few years or even decades) outdated as a model. Innovation in the measure-countermeasure cycle is working at tempo, with several innovations being introduced each month, specifically in the arena of drone and counter-drone technologies.

This rate of innovation is extraordinary and indicative of what has to be developed in the West to create and maintain military advantage, notably in the information domain. Lessons from the conflict between Russia and Ukraine also point to the measure-countermeasure cycle becoming lopsided. Not every development of one side of the divide is naturally matched by another. Sometimes one side of the cycle goes through several iterations of innovation before the other side is able to make a step change in technology to counter the advantage gained. A good example of this is the application of stealth technologies to fighter aircraft. With the dawn of the F-117 Nighthawk fighters and their use in the first Gulf War, stealth technologies gave the West a significant advantage in terms of freedom of manoeuvre over Iraqi skies. Iraq's Russian-developed air defence systems' weaknesses were graphically on display and air defence weapons resorted to firing randomly into the sky in the hope of hitting something.

After the first Gulf War it was inevitable that the Russians would consider the lessons they needed to learn and develop countermeasures to negate the advantages of stealth technologies. The result of this created what is, arguably, a step change in air defence systems. The Integrated Air Defense System (IADS), which is networked and has a multilayer approach to the protection of a specific area, is regarded as a national significance.

Information superiority over stealth?

Through the development of IADS, the Russians began to negate stealth technologies. By networking sensor systems, the opportunities to exploit points in an aircraft's flight profile, such

◀ Tempest's next-generation radar system (part of the Integrated Sensing and Non-Kinetic Effects – ISANKE system) will collect and process 10,000 times more data than current fighter radars.

BAE Systems

as manoeuvring, made the stealth technologies less effective. Underpinned by a sophisticated and resilience of communications capability, the Russian IADS gained a formidable reputation in the West.

NATO planners were concerned that the IADS capabilities also removed NATO's traditional advantage in the close air support environment. The development and deployment of the IADS capabilities changed the military balance of power in Europe. Means by which the central node of these systems, the S-400 Triumf system and allied system, such as Pantsir, could be attacked and destroyed, became, and remains, a priority for long-range fires.

Recent successful attacks against the Russian IADS have shown that the measure-countermeasure cycle is moving forward again.

The shooting down of an Azerbaijan Airlines' aircraft on Christmas Day 2024 also points to an inherent fallibility in Russian technologies that underpin the IADS capabilities.

Any air defence systems, irrespective of how it is connected and made resilient, can still run out of air defence missiles when faced by a swarm attack involving a mix of airbreathing and ballistic missiles.

This issue of survival in what is a hostile air defence environment, which is further complicated by the threat from pop-up Man-Portable Air Defence Systems (MANPADS), is central to the current design problems being faced by those designing the sixth generation of fighter aircraft, such as the multi-national Global Combat Aircraft Programme (GCAP) or its equivalents in the US.

The recent flight in China of what appears to be a new combat aircraft (shown without a tail), illustrates a crucial point. Stealth technologies are, irrespective of measures designed to protect Western technology, being developed by our potential adversaries. Stealth technologies are no longer the preserve of the West.

In such a situation, how does the West seek and retain the advantage in what is increasingly becoming a hostile battlefield? Contemporary warfare has become a battle for information advantage. Ideally, at some points in conflict, this should turn (albeit briefly) into information superiority – a point which needs to be recognised and exploited with immediacy. This is the preserve of the *coup de main*, the point at which a military commander can deploy assets and even reserves to achieve a decisive breakthrough or force an opponent into culminating their forces to their disadvantage.

information superiority

US Navy

As the lines of aircraft inevitably, like automobiles, start to look somewhat similar, so it is to the field of computing and the application of artificial intelligence (AI) and machine learning (ML) that Western aerospace designers should turn to retain an advantage. The military axiom that they, who move around Boyd's Observe, Orient, Decide and Act (OODA) loop, still applies. This is how information advantage is created and how the conditions for passing moments of information superiority can be recognised and exploited.

As Congress and the Trump administration grapple with defining the requirements for the sixth generation of USAF and US Navy aircraft, and GCAP comes under increasing scrutiny, it is advances in computer technologies applied to sensor systems that will help secure the information advantage military commanders seek.

Crewed and uncrewed platforms

Crucial in creating a solution to this dilemma is the creation of a balance between crewed and uncrewed platforms and the role they play on the future battlefield. In military circles, the axiom that mass has its advantages also still applies, a clear lesson that is repeated almost daily in the war in Ukraine. Whereas in the past, investments in stealth technologies have inevitably seen numbers of aircraft deployed reduced so, therefore, the introduction of the 'loyal wingman' can offer a better balance between crewed and uncrewed aircraft.

▲▲ A BAE Systems Autonomous Collaborative Platforms (ACP) concept for an uncrewed 'loyal wingman' aircraft.

▲ The US Navy's Next Generation Jammer (NGJ) provides capability in three increments: Mid-Band, Low Band and High Band frequencies. This allows it to disrupt, deny and degrade enemy air defence and ground communication systems at longer ranges.

In the US, a hot topic of debate is how expendable is the uncrewed element of this new force structure. An excellent question is: what is the mix between simple drones that are built to be expendable and those that are most survivable?

The heart of this debate is how autonomous the uncrewed elements of the force need to be to be effective. Are they simple decoys that can present a profile to a Russian IADS system of sufficient quality to cause them to expend a missile, depleting their immediate stocks, or are they capable of carrying sufficient jamming power to play a role in the Suppression of Enemy Air Defenses (SEAD) operations? In trying to achieve a suitable balance, it is vital that any application of AI and ML technologies is based upon an ability for that capability to be upgraded. It is in the software space of AI and ML systems where the most rapid developments, in contact (ie at war), will occur. This point has been highlighted from the rapid pace of technological innovations occurring in Ukraine. Its rapidly expanding cottage industry that supplies ever more sophisticated drones and missiles able to attack targets deep inside Russia is testimony to this approach. Core to AI and ML systems is the training set on which they operate. This is driven by the quality of the intelligence data collected by sensor systems. This can be subject to delays in the 'Intelligence Cycle'.

The exploitation of intelligence, such as through updating the training set in an ML application designed to provide a robust radar warning capability for a NATO ground-attack aircraft operating in a complex IADS environment, can be cumbersome. Gone are the days when Tornado aircrews would walk out to their cockpits with an updated cassette tape containing the results of the latest intelligence collection activities on the operations of adversarial air defence radar systems that are loaded into the Radar Warning Receiver (RWR) before take-off.

Today, by using AI and ML technologies, advanced systems are designed in such a way as to make plug-and-play concepts work. The sixth generation of fighter aircraft and their uncrewed escorts will reply on the technologies that enable the latest and best algorithms to be deployed into service. It will not be about data alone offering the advantage but, the advances in data processing and its speed of analysis, where the crucial advantages need to be gained and maintained. This includes the deployment of ways that safeguard the integrity of the algorithms and data that underpin the AI and ML technologies from exploitation, in development (through cyber-defence measures) and in combat as units are lost to enemy action.

An ongoing process of refinement

While it is easy to say the whole point of the measure-countermeasure cycle is that once an advantage has been secured it must be sustained, that does not mean standing still and resting on one's laurels. It means continuous improvement, operational validation and deployment at tempo.

Critically, where information advantage through algorithm superiority is to be achieved, where uncertainty exists in the training data and in operations, where sensors are operating in traditionally low signals to noise ratio environments, such as those, is where confrontation is also occurring in the Electronic Spectrum.

Arguably, in Ukraine, one of the most crucial recent developments in this field exploits high-resolution, geographically aligned imaging technologies to provide the precise aiming information needed to attack specific targets with a high degree of precision. Whereas that technology is routinely available in advanced, long-range strike missiles deployed by the West, Ukraine has had to innovate at speed as restrictions on the use of Western supplied missiles hampered the nation's operational freedom of manoeuvre. The results of the rapid and successful exploitation of this field, specifically rapid software updates, are seen on social media platforms as Ukrainian military forces attack significant targets deeper inside Russia.

Ultimately, while this battle for information advantage will inevitably be fuelled by the use of ML and AI systems, it is right to point out that these technologies are still in a state of development. It cannot be said that AI and ML technologies have yet reached a state of operational maturity across defence applications but there are areas in which progress is being made.

The next generation of radar technologies will be able to adapt many of its operating characteristics on a pulse-by-pulse basis – optimising the detection of a signal against a noisy background, such as that created by the sea or the land environment. High-resolution visual and infrared detection systems are

▶ Rendering of Tempest's information-sharing capability.

▲ The modern air defence environment is complicated by the threat from pop-up Man-Portable Air Defence Systems or MANPADS.

Leonardo

Boeing

◀ Boeing sees its F-15EX as a 'quarterback' for its MQ-28 CCA – with the rear-seat WSO able to command these drones.

being increasingly supported by algorithms that can use spectral manoeuvre to combat the deployment of, *inter alia*, camouflage.

AI and machine learning

This all points to the introduction of self-learning systems using AI and ML technologies, those that can self-adapt in real time. In the AI and ML world, this is not totally straightforward but rather it is a matter of optimisation. Where to look for a maximum signal-to-noise ratio against a target that has deployed stealth technologies or, is adaptively jamming signals in the electro-magnetic spectrum, at tempo, is a crucial optimisation problem for AI and ML systems, which can become stuck in what are known as sub-optimal solutions, a classic problem that arises from solutions based on calculus.

This is an area where genetic algorithms offer a new paradigm. Whereas neural network systems have been at the forefront of advances in ML, their limitations in an operational context are now becoming better appreciated. Issues of bias in an original training set and the phenomenon known as catastrophic forgetting (where self-adapting systems forget important parts of their training set as they collect new data) are also challenges at the forefront of these technologies. This is known as the plasticity-stability dilemma.

In trying to replicate the operations of the brain and how it works, the balance between plasticity and stability is vital. Both are qualities processed by experienced human operators that need to be replicated in the next generation of AI and ML systems. Genetic algorithms have emerged from the challenge of balancing plasticity and stability (the traditional home of the neural network solution). For sensor systems on sixth-generation fighters to be capable of achieving information advantage and, through fusion with information derived from other sensor systems, getting to the nirvana of information superiority and using adaptive systems, such as genetic algorithms, offer a way forward.

Modelled on the idea that algorithms, like species, must adapt to their (changing) environment on the battlefield as the measure-countermeasure cycle evolves (albeit erratically), the DNA of the algorithm adapts to achieve a fitness function that offers an optimal response. The crucial point of genetic algorithms is that they can be created in parallel, not in series, offering the potential for self-adapting systems operating in real time.

Summary

In summary, as military planners and political leaders struggle with the leap required to sustain combat advantages in an ever more rapidly changing world and seek to get the best value for their investments in that technology, it is increasingly clear that the information space is going to be crucial as an environment in which to manoeuvre at tempo.

Lessons emerging from Ukraine provide clear evidence of the importance of this domain. Solutions based upon the next generation of operational ML and AI systems are going to be crucial in achieving information advantage and information superiority. Investments in the hardware and software technologies that enable the deployment of these capabilities are an essential element of the overall development of sixth-generation aircraft systems and, gaining and maintaining an operational advantage, at tempo, against the backdrop of the pervasive measure-countermeasure cycle.

Jonathan Clare/RAeS

Innovation and adaptation

RAeS Head of External Affairs, **JONATHAN CLARE**, reviews the latest insights from front-line rotorcraft operators attending the Global Defence Aviation Conference in Warsaw.

Held in Warsaw from 21–23 October 2025, the Global Defence Aviation Conference (GDA25) brought together over 900 delegates, 100 industry exhibitors, and aviation military representatives from 85 countries to explore how Uncrewed Aerial Systems (UAS) and military rotorcraft are reshaping modern air power.

Across three days, delegates discussed the technological adaptation, driven largely by lessons from Ukraine and rapid advances in autonomy, electronic warfare (EW) and manned-unmanned teaming (MUM-T).

RAeS industry partners and supporters participating included BAE Systems, Airbus, RTX, Leonardo, General Dynamics, Safran, Thales, Martin-Baker, Lockheed Martin (Sikorsky), MOOG, L3Harris, Northrop Grumman, Boeing, Artemis Smith Myers, QinetiQ, Anduril, Inzpire, Saab and Vertical Aerospace, among others.

The opening plenary set the tone. As one speaker noted, "recent incursions into Polish airspace by Russian drones have brought a note of even greater urgency into national modernisation efforts." Poland, like many of its allies, is accelerating innovation timelines to defend against proliferating drone threats from Russia.

Among the first to present was Leonardo, showcasing its Proteus autonomous UAS under joint development with the Royal Navy. With its first flight scheduled before the end of 2025, Proteus has a modular payload bay, enabling missions ranging from ISR and ASW to logistics. This flexibility demonstrates the new design philosophy underpinning next-generation military aviation: modular, scalable and mission-adaptive.

The UK's forthcoming *Defence Investment Plan* was a recurring theme during the conference. Following the 2025 *Strategic Defence Review*, the UK has pledged to "break the single-silo approach" by accelerating acquisition cycles and, with a newly established National Armaments Director, to streamline procurement which is intended to keep pace with rapid UAS development and rotary innovation. Interoperability and collaboration with all allies are now critical, as "the UK works in coalition, NATO first but not NATO only."

▲ The Global Defence Aviation Conference saw more than 900 delegates from 85 countries convene in Warsaw to discuss military UAS and rotorcraft.

> "THE FIGHT TOMORROW WILL NOT BE WON BY WHO HAS THE MOST ADVANCED DRONE, BUT BY WHO USES IT MOST EFFECTIVELY

DEFENCE LEADERS | GLOBAL DEFENCE AVIATION
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Airbus

Bell Textron

▲ Airbus Helicopters began flight-testing of the H160M Guépard in July this year. The militarised version of the H160 is being developed for the French Armed Forces as part of the Joint Light Helicopter programme.

The Czech Air Force reported progress toward IOC for its new Bell UH-1Y Venom and AH-1Z Viper fleets by 2026, with pilots now training in counter-UAS missions based on air combat experience from Ukraine.

Bottom left to right:

This Ukrainian Mi-24 attack helicopter has been used as a drone hunter and has destroyed over 100 Russian drones, including Shahed/Gerbera types and other fixed-wing UAVs. Each confirmed kill had been marked with a separate kill marking until the crew ran out of space of the fuselage and had to switch to grouped tally bars to continue recording the its victories.

The author with Emiliano Pellegrini, Army Aviation Combat Air Branch, Joint Air Power Competence Centre.

France, meanwhile, reinforced its belief in the enduring relevance of crewed helicopters within a "dronisation" of its military forces. The H160M Guépard programme, developed with Thales and Airbus, has achieved a first prototype flight. Deliveries are expected by 2029, marking a step toward operational crewed-uncrewed teaming.

Airbus outlined its transition from a traditional OEM to an agile military support organisation, embedding maintenance teams within end user operations and testing new Air-Launched Effect (ALE) systems across France, Spain and Germany. The ALEs, designed for rotary deployment, extend survivability by offering standoff reconnaissance and strike capabilities from safe distances.

From the Arctic to the battlefield, innovation is also being shaped by geography. The Royal Canadian Air Force shared how its recapitalisation programme (2026–2032) must accommodate extreme conditions, with aircraft required to cold-start after 24 hours at -40°C. "In some bases," a speaker observed, "our helicopters are closer to Moscow than Ottawa." Their proposed use of Remotely Piloted Aircraft System (RPAS) for emergency rescue kit delivery in the High North demonstrates how UAS integration is becoming mission-critical, including humanitarian operations.

The Ukrainian battlefield, described as a "live laboratory for modern warfare," dominated discussions. The Ukrainian Army Aviation shared accounts of helicopter operations against drones and loitering munitions claiming over 3,500 enemy UAS being shot down in 2025, often with 7.62mm machine guns. Their front-line experience demonstrated that agile, crewed rotorcraft remain highly effective tools in drone-saturated environments: "first of all, you must understand that a helicopter is an effective weapon against drones."

MUM-T, counter-UAS and the expanding battlespace

Themed sessions on defence helicopters, UAS and operational effects addressed a central question as to whether helicopters have a future in a world of drones. Germany is exploring a model where uncrewed systems spearhead missions, clearing paths for crewed aircraft that then act as command nodes for swarming drones. Heavy-lift operations, however, are expected to remain crewed until at least the mid-century. Elsewhere, the French Navy is already automating its logistics while keeping crewed combat platforms for "the element of human unpredictability." Western militaries also acknowledged the pragmatic driver of uncrewed expansion citing declining recruitment rates.

The European Defence Agency (EDA) is working to integrate UAS into European airspace by 2030, focusing on harmonised operations, risk assessment and training. Key initiatives include Eurodrone integration and advancing safe and interoperable innovation for UAS drone operations across the EU. European innovation was also on display through Robin Radar's IRIS Counter-UAS (CUAS) system, which employs Doppler-effect sensors and AI to classify threats with pinpoint accuracy.

The Royal Navy is moving to a dispersed, digitally connected fleet of crewed, uncrewed and autonomous platforms that will "redefine maritime military power." As one speaker asserted, "the fight tomorrow will not be won by who has the most advanced drone, but by who uses it most effectively. The human factor will remain the deciding factor."

General Dynamics presented AI-enabled UAV innovations integrating mission planning, swarm autonomy and adaptive EW. The session focused on digital-open-architecture systems delivering

Ukrainian MoD

Via Jonathan Clare/RAeS

Stephen Bridgewater/RAeS

▲ Leonardo's Proteus utonomous UAS is under joint development with the Royal Navy and its first flight remains scheduled before the end of 2025.

precision and adaptability through multi-sensor fusion, intelligent EW and resilient communications in contested environments with human in the loop targeting: "AI can make decisions quickly but humans still need to be involved to enforce rules of engagement."

Other highlights included Northrop Grumman's Common Infrared Countermeasures (CIRCM) survivability system demonstration, showing live missile footage veering off course when countermeasures were engaged, and Frontex's plans to extend UAS border surveillance to high-altitude systems by 2026. The NATO Support and Procurement Agency discussed joint procurement of MQ-9B advanced, next-generation RPAS emphasising interoperability: "by the time we need it, it is going to be too late and that is why interoperability has to be built in from the start."

Finally, real-world MUM-T examples were featured by Skytrac, which has integrated Schiebel rotary-wing drones with the UK Coastguard for maritime SAR operations, transmitting real-time video via Starlink and Iridium satellites. Meanwhile, research into anti-icing technologies for UAS highlighted the challenges of extending endurance and safety in adverse conditions, especially at high altitudes and cold latitudes.

Combat lessons

The final day revisited Ukraine's air war, where the convergence of drones and rotorcraft has forced rapid adaptation in tactics and training. Drone attacks have become ubiquitous with up to 433 launched daily, while counter-drone measures range from electronic warfare to kinetic interception by helicopters. "The air war is getting closer and closer to the ground," one speaker summarised, adding "air power is like oxygen – when you have enough, you don't think about it; when you don't, it's all you can think about."

The Finnish Utti Jaeger Regiment showcased the importance of readiness and hybrid warfare capability, having recently supported counter-shadow fleet operations in the Baltic Sea. Its integration of naval, police and special operations skills illustrate the growing interplay between military and civilian domains.

The Joint Air Power Competence Centre's lecture reviewed helicopters versus drones in the Ukraine-Russia conflict, detailing operational ranges and types from short-range FPV to long-range Shahed/Geran systems. Counter-drone measures were examined, including jamming, nets, drone-on-drone tactics and anti-drone artillery. The presentation highlighted direct co-ordination between Ukrainian industry and tactical units to accelerate innovation and institutionalise drone strategies within NATO frameworks.

The Kharkiv National Air Force University included an informative session detailing how it has sustained education programmes during the conflict through remote learning, AR/VR simulation and even combat mobilisation of staff and students.

The Israel Defense Forces (IDF) provided some sobering insights. Reflecting on the 7 October attacks, the IDF recounted helicopter crews coming under fire en route to Gaza and emphasised the need for realistic, adaptive training. "When conflict arrives, its nature will be unexpected," one officer warned. Their experience reinforced that rotary platforms remain indispensable for rapid troop transport, medevac and counter-UAS missions even in environments saturated with drones.

The concluding plenary turned to electronic warfare. With UAS now operating across frequencies from 150MHz to 2,700MHz, counter-jamming has become a complex, power-intensive task requiring multiple EW systems per vehicle. Delegates were also reminded of the dangers of digital signatures on the battlefield: "a cluster of mobile phone signals can be as deadly as a flare!"

Industry sessions closed with Sikorsky's unveiling of the Nomad UAS family and the S-70UAS U-Hawk prototype, a fully autonomous rotorcraft capable of lifting 10,000lb payload from missiles to uncrewed ground vehicles. This leap forward in vertical logistics automation represents one of the clearest signals yet of how AI and autonomy are transforming rotary operations.

Summary: Technology, teaming and the future force

Across three days, GDA25 provided a panoramic view of how the global defence aviation community is grappling with the interplay between autonomy, connectivity and human judgement. From Leonardo's modular Proteus and Airbus' embedded ALE systems to Sikorsky's autonomous U-Hawk, the message was consistent – technology is advancing fast but operational success still depends on the adaptability of people and systems together.

One defining sentiment of the conference came from the Royal Navy, which reminded participants that "the future force will be hybrid–uncrewed where possible, crewed where necessary, but always human-led."

As the world's air forces adapt to drone proliferation, electronic warfare and AI-enabled decision loops, the balance between machine speed and human insight will determine who achieves air superiority in the battlespace of tomorrow.

The Society looks forward to further discussions on UAS, AI and air power with senior military experts and government officials in the run-up to the RAeS Annual Defence Summit in May 2026.

> THE FUTURE FORCE WILL BE HYBRID-UNCREWED WHERE POSSIBLE, CREWED WHERE NECESSARY, BUT ALWAYS HUMAN-LED

The Future Air and Space Defence Summit Summit, RAeS Conference 20-21 May 2026, RAeS HQ, London

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Raiders of the lost archives

Are today's engineers and researchers missing a trick by not visiting the dusty paper archives of old? Aviation historian Dr **MICHAEL PRYCE** thinks so.

Andy Hay/www.flyingart.co.uk

"Both Concorde and Apollo were terrible ideas and we shouldn't have done them."

So says Blake Scholl, founder of Boom Supersonic. That might sound outrageous to some but not to engineers and historians. Aerospace prestige projects have always been a mixed blessing. Concorde famously bled money, while Apollo did not lead to anything. Both were heavily criticised in their own time as wasteful government projects spending taxpayers' money, but one thing was undeniable – they were fast. Both got the go-ahead in the early 1960s – by 1969 Concorde was flying and Apollo landed on the Moon.

The reason was they attracted the best minds. Whether government funded or commercial, with cutting-edge technical challenges what really matters is who is doing the work.

What is odd is that the commercial disruptors who want to break with this seemingly wasteful past seem to have slowed down. Great promises are made for project deadlines and are often broken. Despite their digital swagger, much of what is sold today as the future of aerospace is just a remix of old, forgotten ideas that sprang from great minds.

Do tech bros dream of electric jets?

Scholl says one of Boom's secrets is to control its "full stack," recruiting engineers steeped in software culture. His company, like others today, trumpets iterative design where you get data from technology demonstrators, even if they fail. Data allows you to optimise and that is what matters. Elon Musk's SpaceX made iteration famous: launch, fail, tweak, relaunch – mirroring how programmers develop code. For commercial innovators explosions can be good PR too, keeping investors on side. It is all data and that is what powers innovation.

Such an approach would horrify old designers. In the past, explosions got projects cancelled.

Scholl and many others hark back to a mythical 'Golden Age,' but, in reality, failure was a thing to avoid. It showed your idea was no good. The de Havilland Comet is probably Britain's most famous example where critical data on metal fatigue came after failures and was seen as a bad thing. The Comet lost the lead in the airliner jet race. No one was trumpeting the new data as the project's salvation. Boeing won instead. Real competition to sell in the market, not to get venture capital investment, was brutal about failure, even with government programmes.

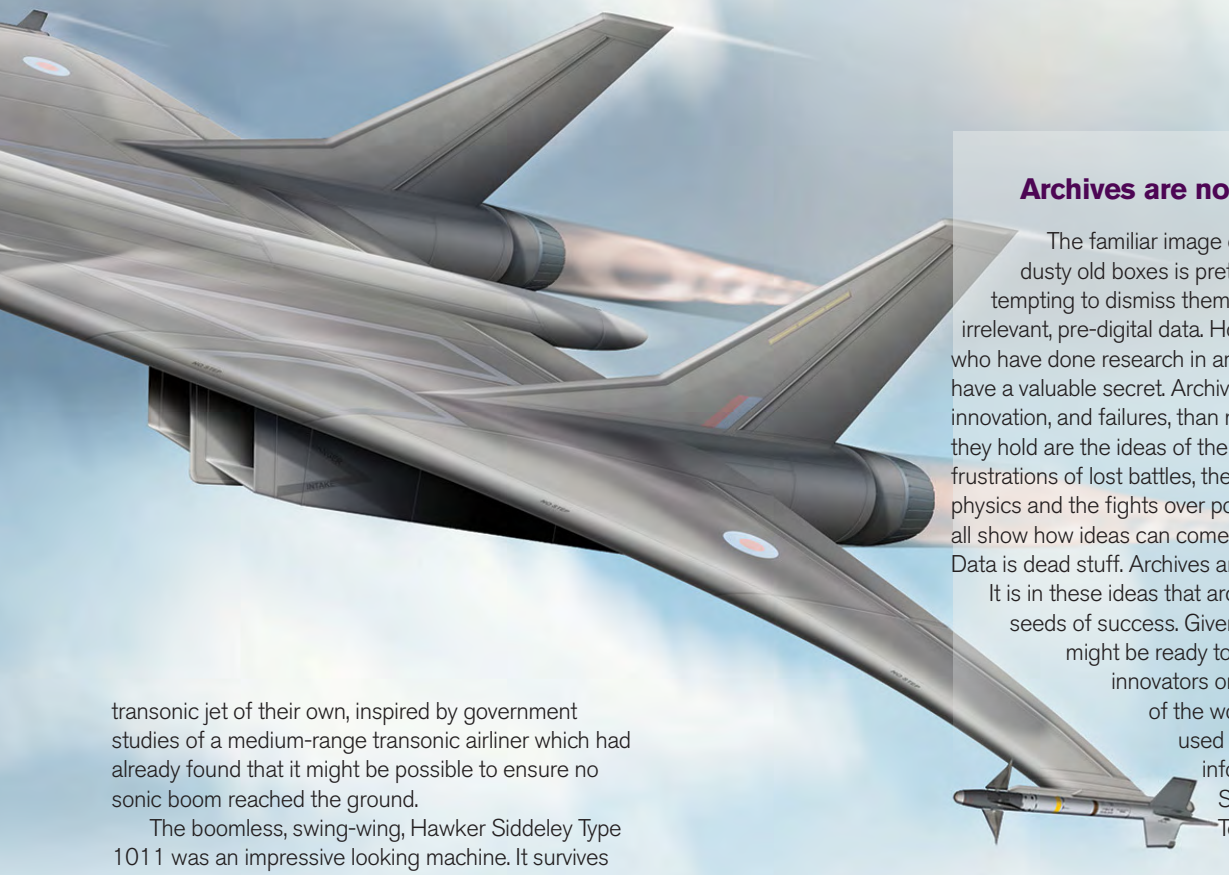
Concorde found that out too. American regulations to limit supersonic overland flights, combined with the oil shock of the 1970s, killed its chances. These regulations have just been rolled back at last, thanks to Scholl's advocacy. Maybe that good idea will help speed Boom's success. The freedom to fly supersonically overland, as long as the sonic boom does not reach the ground, has allowed Boom Supersonic the chance of 'boomless flight.'

The chance of boomless supersonic flight seems like a new and exciting idea, knocking almost 50% of flight times across the US. In truth, it is an idea older than Concorde.

Britain's boomless future – in the 1960s

What seems like an innovation is really an old idea. Dig into the archives and you see that many designers already figured out that boomless flight was possible over a decade before Concorde entered service in 1976.

In 1960s' Britain, Hawker Siddeley Aviation's Advanced Projects Group (APG) pitched for the Concorde contract and lost. They did not mourn. During their studies the company's designers realised that the sonic boom was a big problem that could break windows, scare animals and seemed destined to limit overland supersonic flight. Instead, the Hawker Siddeley designers came up with a 'boomless'



transonic jet of their own, inspired by government studies of a medium-range transonic airliner which had already found that it might be possible to ensure no sonic boom reached the ground.

The boomless, swing-wing, Hawker Siddeley Type 1011 was an impressive looking machine. It survives in model form at the National Aerospace Library at Farnborough. Even after Concorde had flown, Hawker Siddeley revisited the idea, ditching the swing wings for fixed supercritical ones. The company knew a good idea when it saw one, even if the government's Concorde prestige project pushed past them on to Mach 2 and commercial failure.

When Scholl's Boom Supersonic team visited Brooklands Museum they toured Concorde, recruited one of its pilots and got great PR on social media. However, the filing cabinets in the archives that contain the Hawker Siddeley APG's studies went untouched, their design and data for boomless flight undiscovered. Boom Supersonic could have had the 'gamechanging' idea of boomless flight years earlier. Ignoring the old ideas can slow innovation down.

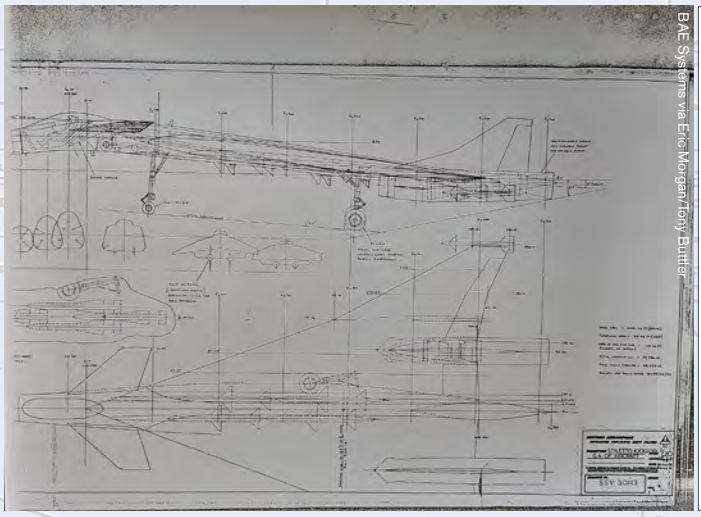
Archives are not dead – data is

The familiar image of archives as full of dusty old boxes is pretty accurate and it is tempting to dismiss them as warehouses of irrelevant, pre-digital data. However, for those of us who have done research in archives, we realise they have a valuable secret. Archives offer a richer record of innovation, and failures, than mere data. The real value they hold are the ideas of the designers' past, their frustrations of lost battles, the struggle to overcome physics and the fights over politics and money. These all show how ideas can come to life and take wing. Data is dead stuff. Archives are not.

It is in these ideas that archives hold the dormant seeds of success. Given air, water and light, they might be ready to grow again or guide innovators on a smoother path. Some of the work I have done in them used ideas from archives to inform the UK's Combat Air Strategy. That has led to Tempest and GCAP.

One outcome of that work was a focus on the use of digital data in design. Almost none of the material in archives is available online. It is invisible to artificial intelligence and large language models, not baked into any computer-aided design tool. Digitising old documents might seem straightforward but we found that it was not. Without understanding the arguments that the archives hold, what the designers were thinking and fighting over, reducing an archive to digitised data has severe limits.

Seventy-five years after his famous 'Imitation Game' paper, Alan Turing's work is also held in archives, so I took a look at it. Turing proved that only certain things can be computed, although he hoped computers could eventually overcome these limits. So far, they have not. Engineering design is more than just sums, and sketched drawings and hand-scrawled



BAE Systems via Eric Morgan/Tony Buttler

◣ The Stiletto only exists in paper blueprint form. It is, therefore, not searchable by AI algorithms.

Background blueprint drawing: BAE Systems via Eric Morgan/Tony Buttler.

British Aerospace Filton Stiletto – 1981

Span	41ft 8in
Length	82ft 2.5in
Height	15ft 6.2in
Wing Area	1,000ft^2
Aspect Ratio	1.726
Leading Edge Sweep	70°/62°
Max Take-off Weight	57,080lb
Engines	2 × RR GN 2216 (0.2 BPR/0.3 scale Olympus 593)
Armament	4-6 long-range AAM, 2 Sidewinders
Cruise Speed/Max Speed	Mach 2.0/Mach 2.47
Cruise Height/Service Ceiling	60,000+ft/80,000+ft
Take-off/Landing distance	1,000ft/1,500ft
Radius of Action @ M2.0	1,600nm
Essential idea	Concorde-based fighter will beat F-15/MiG 25 and SAMs in speed and turning performance thanks to incredible supersonic lift/drag ratio.

◀ Were Concorde and Apollo both terrible ideas?

notes are a huge challenge for AI to interpret, let alone create. Yet these rough ideas are just how archives reveal how humans have ideas.

My own attempts at building an AI agent, to crawl over public-domain material on powered-lift aircraft, has rammed this home. Adding context and real, human understanding is essential. The physical act of sitting in a real archive, following leads, connecting with the thoughts of designers to make serendipitous discoveries, reveals ideas in a way digitising documents cannot. An idea is often revealed by what designers do not say in their memos, holding things back, only hinted at in the scrawled pencil notes on their own personal copy. The data in the formal document can be a deliberate distraction.

The Concorde fighter

The challenges of the Golden Age – jet engines, supersonic flight, rockets and jump jets – were immense. Perhaps that was the attraction, the reason why they attracted the best brains. Another striking feature is how non-linear progress could be. Often it was the unintended outcome, the side quest, that led to an exciting new concept. The Harrier jump jet was born out of boredom with a new supersonic fighter design. The data even said the Harrier was impossible. In a famous quip, Sir Sydney Camm said that the Harrier prototype, the P.1127, would need to work simply, whatever the data said: "We are only ignorant buggers here at Kingston, and don't understand all that science. We'll keep the P.1127 simple and let its pilots fly it." Hawker Siddeley's boomless design was born from a similar approach – a new idea needs to be practical, not just data driven. No one wants their windows broken.

One fascinating outcome of Concorde was a similar project started as a detour, Britain's own Firefox fighter. The 1981 British Aerospace Stiletto looked fabulous. The team who designed it were not the fighter designers at Kingston or Warton but the airliner designers of Concorde at Bristol. They had not built a fighter since their piston-engined WW2 bruiser, the Beaufighter, and, as with all good side-quests, the Stiletto was a long shot. It was not meant for the RAF, rather the USAF's emerging Advanced Tactical Fighter competition, that ultimately led to the F-22 Raptor. At the time, stealth and speed were being traded off and the designers from Filton went hard over on speed and range for their supersonic cruise fighter. They wanted to outrun surface-to-air missiles, not hide from them. Boomless flight would hardly matter in any WW3 scenario but the really striking thing was the use of airliner aerodynamics to create a new type of fighter. It was an idea that went well beyond the wind tunnel data, a real imaginative leap.

Sadly, Britain did not see any need for such an impressive machine. The demand for European collaboration meant we got the Eurofighter Typhoon instead. There were just too many ideas in the minds of Golden Age designers for limited government funds.

Compare the messy evolution of past designs, starting with leaps made by diverted minds, to today's tidy innovation roadmaps. Investors demand data-driven plans in PowerPoint before anything is made, just as governments did in the past. The archives show how the shroud of government secrecy allowed the messiness of design evolution to proceed, much closer to the PR version of innovation we tend to get sold today. Modern pitch decks are neater, but they fence in imagination, limiting the chance to really explore. Aviation's past was less digital, more unplanned, more wasteful it seems but the chaos could be fertile. Rockets to Mars and supersonic or boomless airliners are not new ideas.

Blast off?

While rockets are nothing new, it seems possible that one person who has learned from the past is Elon Musk. There are books based on archive research that show how Wernher von Braun got his Saturn V to

NAL/RAeS

▶ The HSA-1011 addressed the concept of 'boomless' supersonic flight decades before Boom Supersonic.

the Moon. Scholl may see the Apollo as a waste but it is striking just how similar Musk's way of working at SpaceX is to the Apollo engineer's.

From updates about 'what have you done this week?' to the trial and error of iterative design, the past certainly looks like it has provided many lessons in this case. Von Braun's Saturn V team had their own way of working, although NASA eventually brought them to heel through standardised NASA project management and systems engineering. Perhaps that is why they never made it to Mars, the ultimate dream shared by both von Braun and Musk. Imagine trying to take him to heel with spreadsheets and rigid processes.

A famously wide reader, perhaps Musk has read the books and papers of those archival researchers who have told the story of Apollo. The PR of explosions can hide a way to a plan that works and the real value of projects, like Apollo and Concorde.

Feeling Ubersonic

One of SpaceX's initial investors, Peter Thiel, has decried how digital technology, the world of 'bits,' has advanced in recent decades while the world of 'atoms,' physical things, like aircraft, has languished. "We wanted flying cars, instead we got 140 characters," he lamented, referring to the original length of a tweet.

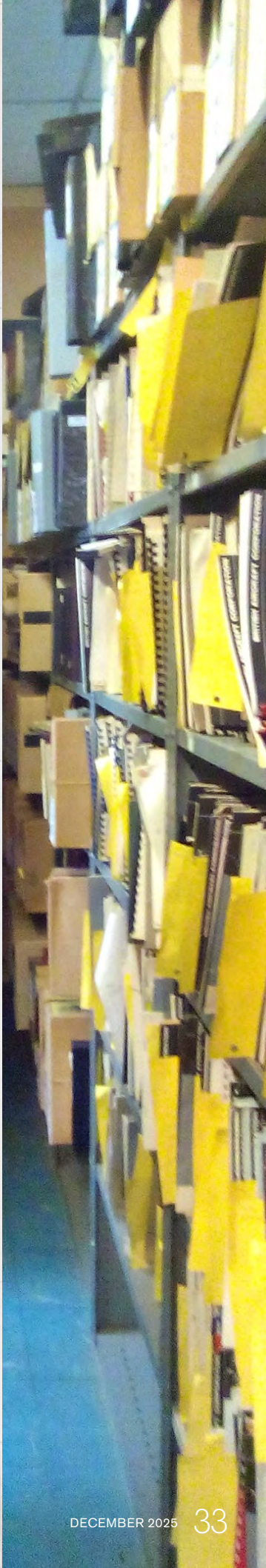
Looking at the archives on the Harrier and related vertical take-off aircraft for my upcoming book, *Jump Jet: The Secret History of the Harrier* (out July 2026), it became clear that the digital stuff, the bits, were the problem. Computers use old data. Anything really new comes from the heads of designers, like those of the Harrier, who were willing to go beyond the data. Even today, the structure of the Harrier is deemed impossible by the industry-standard CATIA computer-aided design tool. Ralph Hooper, who designed the Harrier, knew how to make it work, whatever a computer might say.

By demanding a data-led approach, perhaps Silicon Valley investors are holding back a new 'Golden Age,' rather than leading a new one? There has been apparent progress, often by merging digital with physical, atoms with bits. Programmes, like the VAAC Harrier, a flying laboratory that tested control laws and cockpit displays in the 1980s and 90s shaped the control system for Lockheed Martin's STOVL F-35B Lightning II. Without safe controls no jump jet works – but this was not a pain-free process. The Harrier was indeed designed to let its pilots fly it, in a direct way, despite the difficulties that brought – but it was a famously tricky jet to fly in the V/STOL regime and only the best pilots could do it. A new, digital control system promised greater safety but at the same time it robbed future jump jets of some of the flexibility of the Harrier, something that helped win the Falklands War.

The archives, and interviews, of this work show that the origin of the digital flight control system of the F-35B was full of arguments, verging on bloodletting. Harrier pilots and designers thrashed out the new control idea against the old one. Many preferred the old approach of direct control, Camm's 'ignorant buggers' approach – hardly the sort of phrase to put in a modern pitch to venture capitalists.

Today, eVTOL flying taxis are the closest we have to Peter Thiel's dream of a flying car, and many use the same digital control approach of the F-35B. Meanwhile, the old arguments, and data, sit in archives, waiting to help.

There are many other examples, and recent work has started to feed in lessons from the Harrier and helicopters on the vital area of downwash and outwash for eVTOLs. Happily, some of this work has just won an RAeS Team Silver Medal, but this is not the end of what is possible – it is just the start. Understanding why old arguments matter, which projects can benefit from the knowledge of 'Golden Age' designers, can be a way to flatten speed bumps before innovators hit them. Archives can act as steamrollers to speed up progress.



Apollo		SpaceX
✓	Trial-and-error approach	✓
✓	Failures give focus	✓
✓	'Everything under one roof'	✓
✓	Visionary architect/fixer	✓
✓	Delegated authority	✓
✓	'Weekly Notes' from staff	✓
✓	Shared learning	✓
✓	Build reliability	✓
✓	Technical alternates	✓
✓	Scientific analysis	✓
✗	Project Management	✗
✗	Systems Engineering	✗

NASA

SpaceX

See:

Johnson, S.B., Technical and Institutional Factors in the Emergence of Project Management, International Journal of Project Management (2013)

Sato, Y., Local Engineering and Systems Engineering: Cultural Conflict at NASA's Marshall Space Flight Center, 1960-1966, Technology and Culture (2005)

Don't look back in anger

It always amazes me that innovators avoid archives. Perhaps the need to deliver the shock of the new to investors is too seductive. Disruption attracts headlines and funding, and offers the chance to look like you have something to offer that old companies, old tech, and old ideas do not. Saying some old engineer or company got there first does not look great in a pitch deck. Who invests in old stuff? Added to that, old companies may still control the intellectual property of their own, old ideas. It can be a minefield.

Maybe it is because modern disruptors are digital natives that they want the latest numbers to crunch, not old ideas to wrestle with. It is hard to pitch an ongoing argument rather than a clear proof supported by data that seems to give an answer. The good investors do see it is the people that matter more than their pitch but really it is what ideas those people can grasp and wrestle with that matters most. Boomless flight is one such argument where a look in the archive could have set free new ideas faster than waiting to rediscover them in flight test. The archives could have saved innovators both time and money - the numbers that really count.

Concorde, and Apollo, were not terrible ideas: they just did not work out as hoped. Dismissing what you can learn from them seems like a truly terrible mistake.

Raiders of the lost archive

The 20th Century teemed with designers unafraid to be wrong. Some were ridiculed, some bankrupted and some simply failed. Helicopter pioneer, Igor Sikorsky said: "The whole art of aeronautics, all of man's accumulated experience in mechanical flight, has contributed to the development of direct-lift operation." He did not see the helicopter as a disruption but as part of a continuum of knowledge and experience.

Today, too much effort goes into the repetition of past ideas, reinventing the wheel, rather than learning from them to genuinely advance. The 'digital dudes' just repeat other people's greatest hits. I used to find Harrier records on dirty, dusty shelves in the old acoustic chamber at Brooklands. I was told that famous rock artists used to record in there too. Today, a Concorde stands outside, as seen by Blake Scholl. Imagine not just seeing what they made, but 'getting in the studio' to jam with the ideas of R J Mitchell, Kelly Johnson or Ralph Hooper too? That is what archives offer.

Innovation in aviation is more than just digital tech. The first use of Alan Turing's Pilot ACE computer was to design a supersonic fighter, the English Electric P.1, which became the Lightning. For aviation, digital is already old, its story another one in the archive. Alongside it is another story – the thoughts of the men and women who dared to imagine what digital technology cannot. The archives preserve their ideas, scribbled in pencil, something greater than data.

The real tech revolution might not be about AI models, bigger data or ever more compute. It might be about finding the filing cabinets that have the real treasure. The most disruptive act in aerospace today may be to admit that the future of flight has already been drawn, not on a screen, but in the minds of people who we can still learn from. We just need to look for it in the archives.

Coming in July 2026: *Jump Jet: The Secret History of the Harrier* by Dr Michael Pryce

13 January 2026

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Soaring green

Business aviation generates criticism from all sides of the spectrum, whether it is about its high cost or poor sustainability history. **TARIYE ORIANZI** argues the industry could soar ahead and make a better name for itself.

Business aviation does not often feature in sustainability success stories. More typically, private jets are cast as symbols of inequality – carbon-intensive and out of step with climate realities. That reputation, fair or not, is gaining political traction. France has already banned short-haul domestic flights where train alternatives exist and is weighing new taxes on private flying, and similar policies are being debated across Europe. To put the debate in perspective: commercial aviation contributes roughly 2% of all global man-made carbon emissions. Business aviation, in turn, makes up 2% of that aviation footprint amounting to around 0.04% of total global emissions. However, perception rarely hinges on percentages. The question is no longer whether scrutiny will grow but how the industry responds when it does.

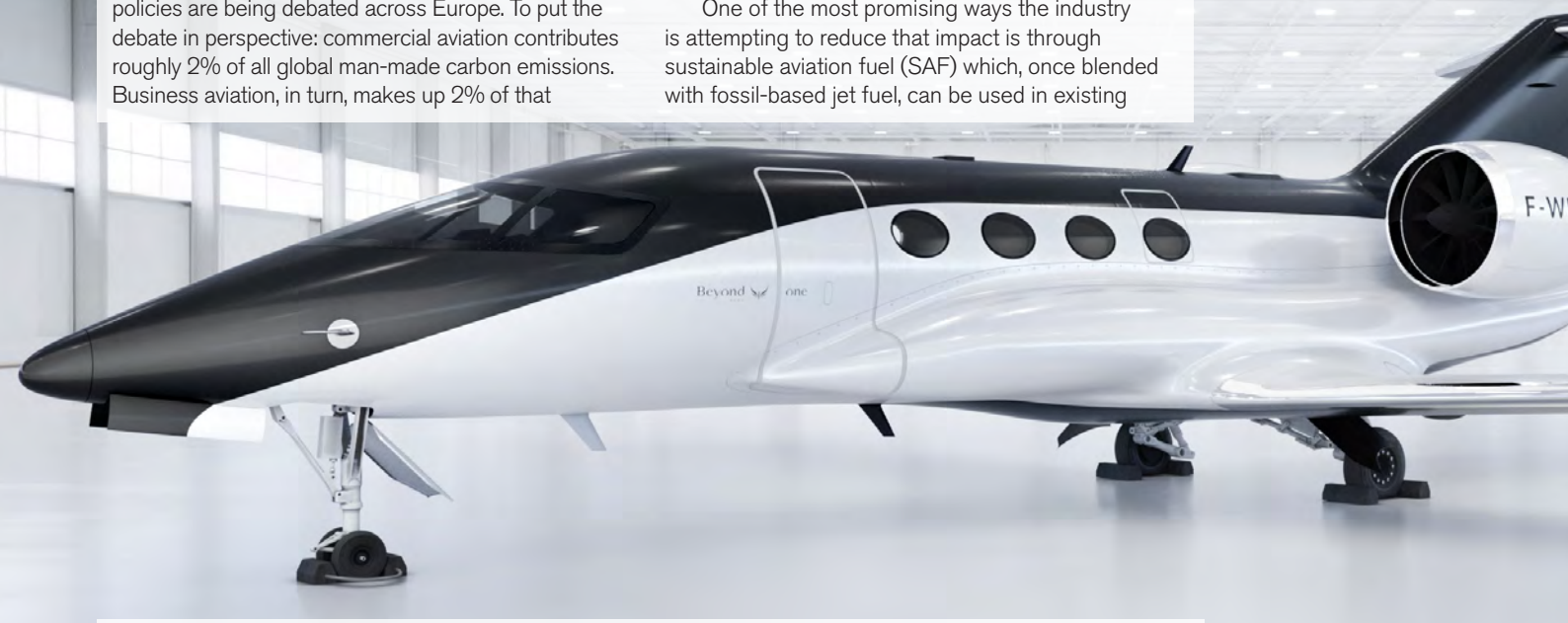
Going a step further, business aviation enables critical-use cases: emergency organ transport, disaster response and life-saving medical flights, which take place roughly 70 times daily across Europe. It is a humanitarian necessity. Business-wise, companies can access hard-to-reach locations, save time and maintain privacy. That does not excuse the environmental impact but it does complicate the conversation.

One of the most promising ways the industry is attempting to reduce that impact is through sustainable aviation fuel (SAF) which, once blended with fossil-based jet fuel, can be used in existing aircraft without any engine modifications and reduce life cycle carbon emissions by up to 80%.

The challenge? SAF remains scarce and expensive. As of now, it accounts for less than 1% of global aviation fuel consumption. Europe has introduced a 2% SAF mandate on departing flights. Asia lags behind with countries, like Singapore and Thailand, planning to start at just 1% in 2026. South Korea will begin requiring SAF in 2027, and Japan aims for 10% by 2030. These are early days and the gap between ambition and infrastructure is wide.

Still, there are reasons for optimism if you know where to look. New-generation aircraft, like the Dassault Falcon 8X, Gulfstream G700 and Bombardier G7500 are leading in fuel efficiency, emissions performance and design. They make up some of the most sustainable private jets on the market, and they appeal to clients who want comfort and conscience. Lighter turboprops, like the Pilatus PC-12 NGX, also demonstrate how

▼ Toulouse-based start-up Beyond Aero is hoping its hydrogen-powered BYA-1 business jet will change perceptions of the bizav industry.



An ongoing tension

From inside the charter aviation world, it is easy to see why this tension exists. Private flights produce disproportionately high emissions per passenger. They are expensive, exclusive and, for many, unrelatable. On the other hand, business aviation connects 1,400 airports in Europe alone, 900 of which see no commercial service.

In the UK, the aviation sector employs over half a million people with approximately 58,900 of these jobs coming from the business aviation sector and contributing more than €11bn in economic output annually. It is an economic necessity.

▶ Business aviation connects 1,400 airports in Europe, 900 of which see no commercial service, such as the UK's London Oxford Airport.

Beyond Aero

short-haul charters can minimise fuel use without compromising capability.

Bizav's competitive edge

Unlike commercial airlines burdened by massive fleets and rigid operations, smaller charter operators can innovate faster, whether by adopting SAF early or rethinking their aircraft entirely. Whichever the case, the spirit of innovation is increasingly visible. Otto Aviation, for example, is collaborating with Flexjet to bring 300 Phenom 3500s into service. The unique selling point of this carbon composite aircraft is the aerodynamic efficiency that is projected to cut emissions by up to 60%. Bombardier is also experimenting with blended wing body designs, aiming to reduce emissions by 50% and Boeing is retrofitting retired 747-8s into long-range private jets using Dreamliner technologies, demonstrating that sustainability is not always about starting from scratch.

HondaJet

▲ The adoption of SAF has the potential to not only reduce bizav's environmental impact, but also improve its green credentials.

Hydrogen propulsion is also nearing feasibility, with Beyond Aero securing interest in its zero-emission business jet. Meanwhile, eVTOLs are poised to challenge the VVIP helicopter market on dense routes, such as Cannes to Monaco or Silverstone and Royal Ascot transfers. These are not speculative side projects – they represent a shift toward a more responsive, lower-carbon future. It may not be perfect, but it proves that innovation can take many forms.

Yet, one of the biggest and often overlooked climate issues in private aviation is not what aircraft to fly but when and why. Repositioning flights, often called 'empty legs,' are a major inefficiency. These are flights made without passengers, typically to return to base or pick up clients. They may be invisible to the customer but carry a significant emissions cost. Addressing this does not require new technology, just smarter scheduling. Dynamic pricing, passenger-matching platforms and cross-operator sharing could reduce unnecessary mileage. Every empty leg avoided is a direct, measurable sustainability win.

> IF WE FLY SMARTER, MEASURE BETTER AND ACT SOONER, THERE IS STILL A CREDIBLE PATH TO A CLEANER HORIZON

Small changes, big rewards

This is where charter companies can begin to make a real difference, not with lofty declarations, but with practical actions. They can start by measuring what they already do: track fuel burn per flight, log empty-leg frequencies and understand which aircraft underperform on efficiency.

They can design their fleets strategically, prioritising models that meet both mission and emissions requirements. Even smaller moves, like partnering with FBOs that stock SAF or participating in book-and-claim programmes (where you pay for SAF that is used elsewhere but credited to your operation) can position them ahead of regulation.

Transparency matters too. Clients are increasingly asking how their travel choices affect the planet. Being able to show them accurate emissions data, offer SAF opt-ins or explain why a Falcon 8X burns less fuel than a 15-year-old Gulfstream builds trust and signals leadership. Charter companies could even offer certified 'green routes' or packages – a trip powered partially by SAF, scheduled to avoid repositioning and flown on a modern, efficient jet.

None of this will erase the inherent emissions of private flying. Critics will still argue, sometimes rightly, that luxury travel for one or two people is hard to defend in a climate-constrained world. However, if the industry wants to survive and remain socially and politically viable, it must get ahead of the narrative. That does not mean overstating its virtues or greenwashing its emissions. It means acknowledging the trade-offs, taking real steps to reduce impact and being transparent about the process. There is a middle path between defensiveness and denial. It is built not on perfect solutions but on steady, honest progress.

So, what does the future look like? Perhaps it is not a world without private jets, but one where their use is better justified, more efficiently delivered and much lower in carbon cost. One where the sector helps lead in SAF adoption, invests in fleet renewal and eliminates unnecessary flights and one where luxury is not just defined by comfort or convenience but by responsibility.

The choices we make now will shape whether that version of business aviation becomes reality. Not all of it is within any single operator's control but much of it is. If we fly smarter, measure better and act sooner, there is still a credible path to a cleaner horizon.

London Oxford Airport

Betting on the F-35

The F-35 may be the world's most popular and advanced fifth-generation fighter – but acquisition and upgrade decisions are still rippling across USAF tactical fighter plans as it manages this complex programme. **BILL SWEETMAN** brings the story up to date.

US tactical air force planning in late 2025 is a confusing picture. The Boeing F-47 (a heavy, long-range, costly aircraft) is going ahead for the US Air Force USAF based on the results of a classified technology programme dating back to 2015. The Pentagon has delayed development of its Navy equivalent, the F/A-XX – a decision that Congress is attempting to reverse. It then declared and reversed its intention to cancel a complementary USAF programme, the E-7 Wedgetail airborne warning and control system – despite increasing recognition of the value of large airborne Active Electronically Scanned Array (AESA) systems in air warfare.

However, at the same time, the USAF fighter fleet is the oldest it has ever been, with most of the inventory still comprising F-15s and F-16s, ordered before the 1991 breakup of the Soviet Union.

The F-35 programme

There is one cause for this: the delayed development and procurement of the Lockheed Martin F-35. The largest defence programme in history – the Joint Program Office (JPO) wrote $36bn in contracts in 2023 alone – has consumed most US fighter investment but has delivered only 500 aircraft to the USAF.

Worse, at least 100 F-35s delivered since 2023 are not combat-ready, because software and a vital sensor system will not be available until 2026. They are part of a major upgrade package that was supposed to be completed in 2026 and was predicted, a year ago, to arrive in 2029. Now, it will not be ready before 2031.

In the early 2020s, the F-35 programme was behind schedule but seemed to be on a stable path. The USAF's plan (adopted in 2017) was to standardise the upgraded Block 4 configuration and increase its orders to 60 a year, to be delivered from 2023. The remaining Block 4 features would be in production by 2026.

However, a punishing September report from the Government Accountability Office (GAO) makes it clear that Block 4 is now at least five years late with no defined schedule, and two years later than the JPO predicted last year. Therefore, for two years and counting, the programme has not delivered combat-ready aircraft, and the aircraft coming off the line are lacking vital software functions.

Frustrated with Block 4 delays and declining serviceability metrics (detailed in other GAO documents and in the final report from the now-gutted Directorate of Operational Test & Evaluation), the USAF has cut its planned FY2026 order in half, to just 24 aircraft.

Plans to start converting existing Block 3 aircraft to Block 4 in 2024 have been shelved, according to the GAO report. This is, potentially, bad news for early international customers, such as the UK, Australia, Norway and the Netherlands, most of whose aircraft are Block 3s.

Where it all began

The problems with the Block 4 programme can be traced to its inception in the late 2010s. It was intended to eliminate obsolescent technology and to meet future threats, capabilities that the USAF considers essential. "We need to make sure that the F-35s we buy have the capability to meet the pacing threat," Chief of Staff, Gen. Dave Allvin told the publication, *Defense One* in July.

The upgrade has two sections. Technology Refresh 3 (TR-3) replaces the integrated core processor (ICP), the central mission computer that controls the sensor system and includes sensor fusion and emission control functions, along with a new memory unit and panoramic display. TR-3 is the foundation for Block 4 an umbrella term for what were originally 66 changes to mission systems hardware, including the EO-DAS all-round vision system, the radar (the new APG-85, for US aircraft only), and the BAE Systems ASQ-239 electronic warfare system.

Lockheed Martin chose to recompete the new ICP, originally supplied by Northrop Grumman. The competition was conducted by Lockheed and there was no avenue for protest, as there would have been in a government source selection. Northrop Grumman did not bid, in the belief that Lockheed was going to award the contract to its own unit in Owego, New York. The winner announced in September 2018 was Harris Corporation, which days later announced its merger with L3, becoming L3Harris. Airborne computers were not Harris' specialty; the unit developing the ICP was the former Exelis, spun off from the ITT conglomerate in 2011 and acquired by Harris in 2015.

Main image: Maj Kristin 'Beo' Wolfe, demonstrates the capabilities of the F-35A during a practice flight at Hill AFB, Utah in 2024.

All images: USAF

L3Harris found that the ICP was more difficult than it expected. The new ICP did not fly on the F-35 until early 2023, when production deliveries were due to start later in the year, and the system proved unstable. F-35 deliveries had to be halted, resuming in 2024 with 'truncated' software usable only for training.

An approved full software suite will not be available until 2026, the GAO reports. The specific limitations of the current release have not been disclosed but it is likely that the most complex high-level functions are missing, such as threat avoidance, target identification and automated intra-flight data sharing.

The ICP problems delayed testing of the Block 4 upgrades, but they had troubles of their own. The JPO and Lockheed Martin decided at the outset of Block 4 to adopt the philosophy known as Agile. Under a single budget line, Continuous Capability Development and Delivery (C2D2), new sensors and software would be contracted separately and introduced in half-yearly increments between 2023 and 2026 (the exception was the new APG-85 radar, supplied as government-furnished equipment). As with the new ICP, all the 60-plus contracts would be awarded and managed by the prime.

GAO objected, recommending that Block 4 be managed as its own major acquisition programme, but the JPO did not change course, and expanded C2D2 to more than 80 items, until acknowledging in 2024 that the effort was disorganised and behind schedule. Then F-35 Programme Director, Lt. Gen. Michael Schmidt told Congress that the Block 4 process was being "reimagined" and scaled back to a "subset of capabilities that give us the most bang for the buck" because "we have signed ourselves up to pipe dreams."

One difficulty was that software fixes had to be used to compensate for immature hardware. Systems that worked on the ground did not perform in flight – indeed, pilots found themselves having to reboot the ICP in mid-air.

September's GAO report indicated that a revised schedule for Block 4, with fewer items and organised as a major sub-programme (adios Agile) would be ready later this year, but that it would not be completed until 2031, five years behind the original schedule, and two years later than predicted a year ago. The cost of the programme is unknown, but the previous estimate for research and development was $16.5bn – 60% of estimated R&D for the all-new B-21 bomber.

GAO noted that a primary sensor, the Next Generation Distributed Aperture System (NG-DAS), will not be ready until 2026, "making it a key driver for capability delays." NG-DAS was another recompeted programme, with RTX winning the contract after incumbent Northrop Grumman declined to bid. NG-DAS is the pilot's primary source

of night vision and the F-35's missile launch warning system.

The news site, *Breaking Defense* also reported in June that Lockheed Martin was concerned about slow deliveries of the new US-only APG-85 radar through Lot 20.

APG-81 radars could be installed as a stopgap.

Delays to TR-3 and Block 4 have affected aircraft deliveries, but supply chain problems have played a part. Engines were delivered an average of 238 days late in 2024, and airframes were 155 days late. None were delivered on time and 2022 is the most recent year where more than half of deliveries were punctual.

Nevertheless, just days after the GAO report was released, the Air Force Association's Mitchell Institute issued a report calling for the USAF to increase its annual F-35 orders to 72 and calling the 24-aircraft FY2026 plan "wholly unacceptable," which did not contain one reference to any delays or problems with the F-35, or to the challenges of accelerating the output of a chronically behind-schedule production line.

Fuelling the fire

Beyond Block 4, the next costly stage in F-35 development is a highly modified engine and the replacement of the power and thermal management system (TPMS), the latter being a complex unit that provides auxiliary power, engine start, emergency power and all cooling. When the engine is running, the TPMS operates on high-pressure bleed air, expanded and cooled through a turbine.

Currently, the F-35 is short of cooling capacity, so the TPMS must extract more high-pressure air than expected from the engine, which causes the engine to run hot and shorten its life. This may account for the fact that the programme bought 140 engines compared to 100 aircraft in 2023, with the extra engines costing about $580m.

Raytheon's Pratt & Whitney (P&W) unit lobbied successfully for a sole-source procurement of an 'engine core upgrade' rather than competition with GE to develop one of the new adaptive engines for future F-35s, arguing that cost and risk would be less, and was subsequently awarded a $1.3bn risk-reduction contract in September 2024.

There is no public cost estimate for the full development contract, due to be awarded in 2027, with the aim of starting production deliveries in 2031.

The upgrade involves replacing the high-pressure section of the engine (the most expensive part) and the gearbox. The GAO has already flagged the fact that the high-pressure turbine relies on two technologies that are only at Tech Readiness Level 5, meaning that only components have been tested. Best practice is to reach TRL 7 before committing to a programme, meaning that the technology has been demonstrated in an operational environment. P&W's PW1000G, has been plagued with problems in its high-pressure section.

Lockheed Martin was awarded a two-year contract in December 2024 to study options to improve or replace the PTMS, now supplied by Honeywell. RTX's Collins Aerospace unit has proposed a competing solution. The goal is to deliver the new PTMS by 2033.

▼ Artist's rendering of the Boeing F-47, the USAF's planned sixth-generation combat aircraft that was released in March 2025.

◢ An F-35A from the 48th FW takes off at RAF Lakenheath. The USAF plans to add a third F-35A squadron at the base in 2028 by transitioning the 494th FS from the F-15E Strike Eagle to the fifth-generation fighter.

> FOR TWO YEARS AND COUNTING, THE PROGRAMME HAS NOT DELIVERED COMBAT-READY AIRCRAFT, AND THE AIRCRAFT COMING OFF THE LINE ARE LACKING VITAL SOFTWARE FUNCTIONS

The JPO has told the GAO that the reduced set of Block 4 upgrades will function with the existing engine and cooling system. The changes will restore engine life and provide margin for future growth, according to the project office.

Lockheed Martin's response has been to talk up the idea of further, more radical upgrades to the F-35. CEO, Jim Taiclet described it in September as "a very active engagement at an extremely high level with the Department of Defense, and I expect it'll be taken to the White House sometime soon." Taiclet has claimed that the so-called "Ferrari" upgrade would integrate technology developed for Lockheed's losing NGAD bid, providing "80% of sixth-gen capability at half the price."

The project might be secret, and the new version might not be available for export, Taiclet said. The capability being touted suggests that it might include the adoption of the adaptive engine.

This proposal might raise eyebrows for some, given that Lockheed Martin and JPO are far behind schedule on a much more modest upgrade package, but the strategy – as viewed from Taiclet's desk – is sound.

The key is the role and position of Boeing's F-47, the NGAD platform announced by President Trump in March with an out-of-sequence designation. Little has been released about the F-47, but the contract award's timing tells us that the major re-evaluation of the project discussed a year ago (*AEROSPACE* November 2024) confirmed the USAF's original concept for a big, expensive, long-range aircraft to engage key elements of adversary air forces and open the way for the rest of the force.

Even if it makes its 2029 first flight date, the F-47 is not going to be available in useful numbers before the mid-2030s. The USAF has talked about acquiring 200-250 aircraft, and the F-47 is not intended for export, so it must choose between a low production rate or, concentrating its annual budget on one programme for a few years (as was originally planned for the B-2).

▶ USAF F-35A display pilot Maj Melanie 'Mach' Kluesner, taxies in at November's Dubai Airshow. Despite the US governent shutdown, plans for the F-35A demonstration in Dubai continued, such is the export importance of the F-35 programme.

All bets are still on the F-35

Either way, the F-35 remains the USAF's only option to maintain numbers in its fighter force, which will otherwise start to age out of existence. Even now, substantial numbers of F-16s will be in service throughout the 2040s. The need for the F-35 will be greater if the F-47 is delayed or the Collaborative Combat Aircraft uncrewed project does not deliver the expected benefits.

The F-35's problems have implications for export customers. All upgrades beyond the final Block 3 configuration are based on TR-3 – new subsystems are not supported by TR-2 hardware or software – but any retrofit programme will be export-only. For the UK, the integration of the Meteor AAM and SPEAR standoff weapon, already pushed beyond 2030, will be further delayed.

These efforts will compete with US needs for already overloaded test resources but, under the production, sustainment and follow-on development (PSFD) MoU signed in 2007, decisions are taken by vote, and votes are allocated according to offtake, so the US can outvote all the other partners.

More recent buyers, like Finland, Switzerland, Germany and Belgium are in a different situation. When they signed up, they expected all 80-plus elements of Block 4 for most, if not all, their orders. They will get less, but how much less they will not know until later this year.

"These were not very bright guys, and things got out of hand" – the classic line from the movie, *All the President's Men* comes to mind all too often in Washington DC in 2025, and planning for future tactical air forces is no exception to the rule.

The next great industrial frontier

The race to establish a lunar economy is here but what will it look like? Will it stand the test of time or just be another moment for flags and footprints? **JOYCE ABANO** investigates how the race to build an economy on the Moon is taking shape.

Nearly six decades after American astronaut, Neil Armstrong took his historic walk on the lunar surface, humanity is planning on returning to the Moon. This time, however, the mission will not just be for scientific purposes; it is about commerce and opportunity.

Across the globe, a new generation of spacecraft, start-ups and superpowers are racing to stake their claim in what many now call the 'lunar economy,' an emerging marketplace projected to reach $170bn within two decades.

"Many people think of the Moon as a scientific destination but today it's increasingly seen as an economic one," says Stirling Forbes, Founder of Europe's space trade consulate, Forbes-Space. "It's a shift from planting flags to building sustainable infrastructure, national security and supply chains that will fuel humanity's expansion into the rest of the Solar System."

From Houston to Beijing, the Moon has become a testing ground for a new kind of frontier capitalism where every rover, lander and drill may one day form part of an off-world economy. The stakes are not just prestige or discovery but about who will own the fuel depots, data relays and mineral rights that could underpin the next century of human civilisation. As Forbes puts it: "This time, we're not going to visit. We're going to stay."

Why the Moon and why now?

Three driving forces are converging to make the Moon more than a reminder of past glory or a time capsule of the space race: technology, geopolitics and economics.

Advances in technology, from reusable rockets and autonomous robotics to In-Situ Resource Utilization (ISRU) and sharply reduced launch costs, have made sustained lunar operations feasible for the first time. Geopolitics is adding urgency, as the US, China, Japan, India and a growing number of emerging players treat the Moon as the next strategic frontier, and underpinning it all is economics: a

◀ A proposed lunar base, developed in collaboration between ESA and the architecture firm, Foster + Partners. The design proposes using lunar soil, known as regolith, as the 3D printed structure's primary building material. This forms a protective shell over an inflatable habitat module to protect occupants from hazards such as radiation, meteorites and extreme temperature fluctuations.

surface rich in resources, like water ice, helium-3 and rare metals, and a position that anchors the cislunar logistics network that could power the next century of space commerce.

"We are witnessing the Moon evolve from a purely scientific outpost into a functional industrial frontier. It is no longer just a destination for exploration; it is becoming part of a broader cislunar infrastructure," Viktor Shpakovsky, an analyst in lunar commerce, a deep tech angel investor and a partner at Beyond Earth Ventures, a venture capital fund focused on frontier technologies with both terrestrial and space applications, tells *AEROSPACE*.

For explorers and entrepreneurs alike, the Moon's allure lies not only in what it offers Earth but also in what it offers beyond Earth. Water ice can be turned into rocket fuel; helium-3 could revolutionise fusion energy; and lunar regolith can be built into habitats. The gravitational barrier is far lower: launching material from the Moon instead of Earth is orders of magnitude cheaper, making the Moon an attractive logistics hub for deep-space missions.

Water ice: The immediate prize. Permanently shadowed craters near the lunar poles contain water ice. That ice can be split into hydrogen and oxygen which, in turn, become rocket fuel and breathing air.

"If you can access that most precious of all resources… you can produce the air and fuel needed for survival and return," says Rich Cooper, Space Foundation Vice President of Strategic Communications. This is not just hypothetical, with NASA's Lunar Trailblazer and the PRIME-1 drill mission mapping and sampling sites for this very reason.

The Moon may hold close to three million tonnes of helium-3, according to some estimates. On Earth, it is virtually non-existent. Helium-3 is prized for fusion reactors (and other advanced uses, such as quantum computing), and companies are already making plans. "I spoke to one company that valued it at $20m per kilogram," Forbes tells *AEROSPACE*. The US Department of Energy and start-ups, such as Interlune, have signed early contracts for helium-3 deliveries by 2030. Yet the challenge is monumental, and NASA's own analysis points out that processing hundreds of tons of regolith or lunar soil may yield only grams of helium-3.

The Moon's soil, called regolith, contains oxygen bound in oxides, iron, titanium and other industrially useful materials. These can be used *in situ* for construction or eventually exported. Extracting Rare Earth Elements (REEs) is more speculative and, while attractive, concentrations may not yet justify economics. Forbes cautions that "rare earth is difficult, at least near surface level."

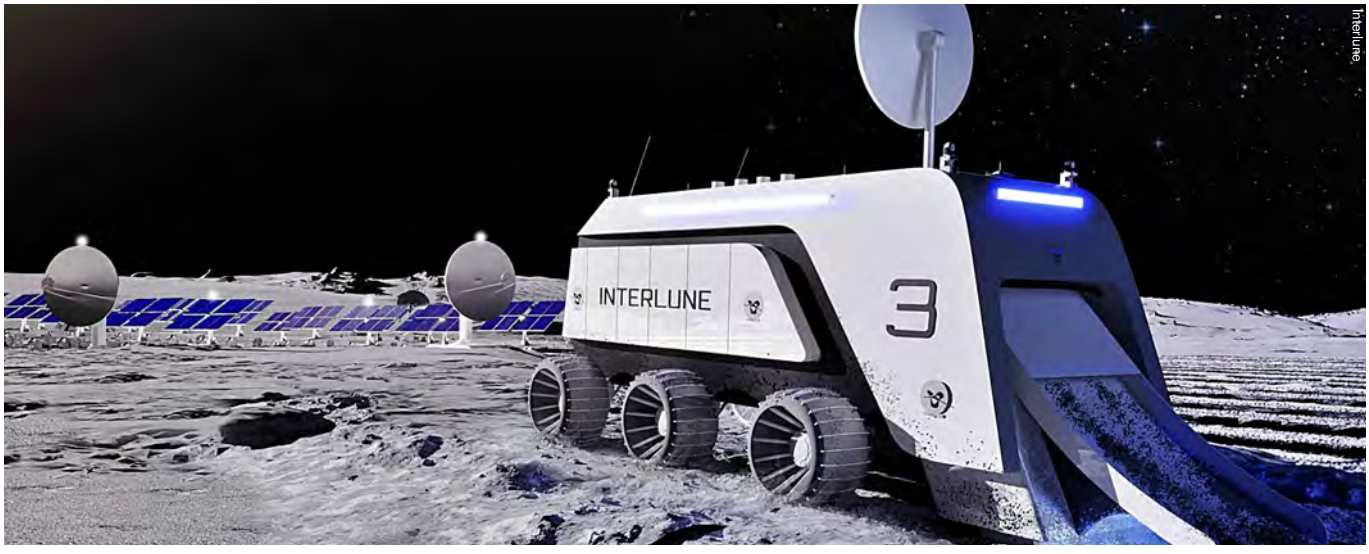
In essence, water and oxygen extraction are near-term, helium-3 is longer term and constructing habitats and manufacturing using regolith is the continuum.

Architecture of a lunar economy

If resources underpin the lunar economy, infrastructure is its circulatory system – the essential network that will sustain all activity on the Moon. Everything from landing pads and power grids to communication relays and habitats will need to be engineered for an environment far more hostile than anything on Earth.

Landing and mobility will form the foundation of this system. Precision landing pads near the lunar poles and equatorial sites will be critical for safe and repeatable missions, while rovers capable of traversing rugged terrain will enable exploration and transport. Reusable vehicles will ferry materials and people between Earth orbit, lunar orbit and the surface. "Over time, we may see 'lunar ports' – standardised pads and charging stations – the beginnings of true lunar ports," Shpakovsky says. These facilities could eventually evolve into logistical

▼ Interlune's robotic rover (shown here in an artist's conception) will dig and sift through lunar soil for helium-3.



Interlune.

Foster + Partners

◀ A key challenge for the emerging lunar economy is not only what gets built on the Moon, but how it gets there, how it is maintained and how such operations can remain cost-effective over time.

hubs that support trade and industrial activity across the cislunar network.

Power systems, too, will define the Moon's early infrastructure. Solar arrays placed along crater rims where sunlight is near-continuous, compact nuclear batteries for shadowed craters and wireless power transfer technologies will all play vital roles.

Start-ups, like Zeno Power, are developing nuclear batteries capable of operating in permanently shadowed regions where sunlight never reaches. According to Forbes, "compact nuclear and radioisotope power systems are enabling humans to live and work long-term on the lunar surface." Reliable power will not only sustain habitats but also drive mining, manufacturing and communications.

Construction on the Moon will likely begin with practicality, not spectacle. The first habitats may not resemble the sleek domes imagined in science fiction. "We won't get futuristic-looking domed houses on the Moon. It will likely be more modular habitats partially buried in regolith," Forbes predicts. Robotic autonomous construction, 3D printing and ISRU will be the key enablers, allowing structures to be built using local materials rather than costly Earth-based shipments.

Communications and navigation will knit the entire lunar ecosystem together. Just as GPS revolutionised life on Earth, a lunar Positioning, Navigation,and Timing (PNT) system will be indispensable for safe operations. Emerging technologies, such as Xona Space Systems' 'Pulsar' network, aim to provide precise navigation capabilities in lunar orbit, Shpakovsky shares.

Telecom relays, laser communication links and lunar internet satellites will ensure that data flows seamlessly between the Moon, orbit and Earth.

"One of the most intriguing abilities now in hand is the use of lasers to transmit and receive communications… information used during a landing or other deployment… could literally be the difference maker," Cooper, an aerospace engineer, explains.

In Europe, Surrey Satellite Technology Ltd. (SSTL) and the European Space Agency (ESA) are working together to develop dedicated communications relays and navigation services for the Moon, effectively building the lunar equivalent of 5G and GPS. This 'Moonlight' initiative aims to provide continuous coverage, precision timing and data links for both robotic and crewed missions, ensuring that future lunar operations have the same kind of connectivity Earth takes for granted.

Together, these interlocking systems, such as transport, power, construction and communications, will transform the Moon from a barren landscape into a functioning industrial outpost. What begins as a series of isolated technologies will, over time, evolve into a self-sustaining infrastructure, the backbone of the emerging lunar economy.

This is lunar architecture. Not architecture in the sense of pretty buildings, but the integrated layout of infrastructure across the surface and orbit, connecting vehicles, habitats, fuel depots and data networks. As Forbes explains: "It's essentially city planning for a new world – creating an interconnected grid of infrastructure built for autonomy."

Logistics and supply chains

A key challenge for the emerging lunar economy is not only what gets built on the Moon, but how it gets there, how it is maintained and how such operations can remain cost-effective over time. Building a lunar supply chain will, in many ways, mirror those on Earth but with far greater complexity, distance and risk. The logistics pathway will likely follow a stepwise

Toyota Motor Company

◀ Toyota's Lunar Cruiser is being developed for the Japan Aerospace Exploration Agency. Powered by fuel cell electric vehicle technology, the four-seater has a potential range of over 6,000 miles on the Moon's surface. The pressurised cabin eliminates the need for space suits inside the vehicle.

model: cargo launched from Earth will first reach lunar orbit, or a cislunar depot, before being transferred to landers for final delivery to the surface. Over time, these depots may serve as refuelling hubs, storing hydrogen and oxygen propellant derived from lunar ice. NASA's vision includes surface 'ports' located near resource-rich sites, connected to orbital depots that facilitate regular transport between the Moon and Earth orbit.

Commercial players, such as Intuitive Machines, Firefly Aerospace and ispace are already helping to lay the groundwork. Under NASA's Commercial Lunar Payload Services (CLPS) programme, these companies are developing reusable landers and surface delivery systems that will support cargo and payload transport.

"These missions are the foundation," says Forbes. "Each one tests technologies, validates business models and builds the flight heritage before anyone commits to billion-dollar mining operations." In practice, robotics will dominate the first decade of lunar commerce, performing tasks too dangerous or repetitive for humans, according to Cooper.

Reducing costs is central to the equation. The viability of lunar operations depends on lowering the cost per kilogram delivered to the Moon. Launching from Earth's gravity well requires a velocity change of roughly 6.8 miles/sec, while launching from the Moon requires only about 1.5 miles/sec, according to studies in robotics and ISRU. As reusable rockets, such as SpaceX's Starship drive payload costs down, the economic case for lunar logistics becomes increasingly compelling.

Sustaining operations in such a hostile environment will also require unprecedented levels of automation and resilience. At the lunar poles, where nights can last 14 Earth days and temperatures drop to -200C, equipment must be dust-resistant, autonomous and remotely repairable. As Cooper puts it, "every crew member will be an ultimate utility infielder, capable of not only doing various jobs but also fixing them when the need arises." Thus, this will not be the glamorous 'flag-planting' of old, but the grinding logistics effort of building roads, refuelling stations and even factories in one of the most hostile environments imaginable.

The legal and geopolitical landscape

Mining the Moon raises legal, regulatory and geopolitical questions. While international treaties and national laws provide some frameworks, many crucial areas remain untested.

The legal foundations begin with the 1967 *Outer Space Treaty* (OST), which prohibits any nation from claiming sovereignty over celestial bodies but allows the use of outer space and the extraction of resources. The 1979 *Moon Agreement* goes further by seeking to restrict resource exploitation, but it has been ratified by only a handful of countries and not by major spacefaring powers. In contrast, the *US Commercial Space Launch Competitiveness Act* of 2015 grants American companies the right to own and sell resources they extract, though not the land itself.

▶ In 2023, Rolls-Royce won £2.9m in funding from the UK Space Agency to develop a nuclear micro-reactor that could be used to support a future Moon base for astronauts.

The *Artemis Accords*, driven by NASA and now signed by more than 50 nations, introduce 'safety zone' provisions and reaffirm the right to extract resources under a 'finders keepers' principle. However, China and Russia have not joined the accords, instead pursuing their own International Lunar Research Station (ILRS) partnership.

"We're about to see not only whoever gets there first with functioning infrastructure, but also how space-related disputes will be handled back on Earth," Forbes notes.

The lunar South Pole is shaping up as the key geopolitical flashpoint. It is rich in water ice and receives near-continuous sunlight, making it a prime target for future bases and mining operations.

"There are maybe a dozen truly prime locations, and in an area without any real accepted international laws, it's a recipe for conflict," Forbes says. How close, for instance, can a US Artemis base be to a Chinese ILRS base? No minimum separation has been defined, meaning each nation is essentially improvising.

"The Moon is becoming a strategic frontier where what's established now will most likely define who sets the pace in space for decades," Shpakovsky adds. The uncertainty also extends to business and investment risks. Resource rights without a clear governance regime may deter some investors, while potential conflicts between mining and scientific preservation could complicate operations. Mining activities might disturb pristine sites that hold immense value for astronomy and geology. The Moon, much like the Arctic, may evolve into a new diplomatic arena – one characterised by both competition and co-operation. In essence, the legal and geopolitical frameworks governing lunar activity are still struggling to keep pace with commercial ambitions. The Moon represents an extraordinary opportunity but also significant regulatory and political risk.

> THE LUNAR SOUTH POLE IS SHAPING UP AS THE KEY GEOPOLITICAL FLASHPOINT.

The first wave of lunar economy actors ranges from government agencies to commercial innovators. Government anchor customers include NASA's Artemis programme, ESA's Moonlight communications plan, China's International Lunar Research Station,

◀ NASA has awarded funds to Texas-based, ICON, to develop construction technologies that could help build landing pads, habitats and roads on the Moon using local lunar resources.

and Russia's Luna initiatives set the initial tone. Yet they increasingly rely on commercial partners. "The space agencies will lay the initial foundations, but it will be the commercial industries that build them out," Forbes says.

NASA, meanwhile, is adjusting its own lunar playbook in a bid to outpace China. The agency recently re-opened bidding for the Artemis lunar landing system, inviting new and existing commercial providers to propose faster, more flexible solutions.

The move reflects the growing urgency of maintaining a US presence on the Moon before China's crewed landing attempt. At the same time, NASA's Space Launch System and Orion spacecraft are expected to be phased out after *Artemis III,* which will complete the first American return to the lunar surface. Beyond that, a sustained US presence will rely entirely on commercial transport systems from SpaceX and Blue Origin, marking a decisive transition from government-led exploration to commercially driven lunar logistics. Start-ups and commercial vendors, include:

- Intuitive Machines and Firefly Aerospace are delivering landers under NASA programmes.
- Lunar Outpost is developing rovers and prospecting vehicles in support of NASA and commercial contracts.
- Zeno Power is working on nuclear-battery systems for shadowed craters.
- Interlune unveiled a prototype lunar excavator capable of processing 100 metric tons of regolith per hour, targeting helium-3.
- ispace (Japan) is collaborating with Magna Petra to develop helium-3 extraction and logistics.

Can the lunar economy pay for itself?

Many funders are watching carefully. The post-Apollo lull taught lessons: unless there is sustained demand, spending collapses. Therefore, private venture capital is stacking the lunar opportunity against multiple revenue streams. With such ambition comes enormous cost and risk. The question is whether the pay-off justifies the bet.

Right now, lunar commerce depends heavily on government demand. NASA serves as an 'anchor customer,' purchasing services from private firms or commercial partners. But no matter how futuristic their visions, one fact remains: their business models still depend heavily on government contracts. Forbes asks the crucial question: "Are we building companies that survive without NASA — or just a fancier version of the cost-plus contractors that made Apollo unsustainable?"

Interlune projects $200m in annual helium-3 revenue by 2030, though Forbes calls that "ambitious." True profitability likely will not come before 2035 when heavy launchers, like SpaceX's Starship, make bulk cargo transport affordable.

Cooper sees the Moon as the next phase of an expanding global space economy that already exceeds $61bn. "If it grows at 7% a year, we'll pass $1tn by 2032," he says, adding that the lunar economy is the next step of that and its dividends will be enormous. Those dividends, he adds, are not just financial. The technologies born from this, whether AI, materials science or energy systems, will touch every community on Earth, just like the first space race did.

But will the commerce hold? Will investors commit billions if the payback is a decade away? Will governments maintain anchor customers or will political winds shift? Will regulatory frameworks mature faster than operations? The winners will be the players that build resilient, diversified business models and are not just reliant on flag-planting or government overspending.

Forbes warns that the 2030s will determine whether there will be commercial momentum or if it will just be another fleeting chapter in humanity's space story.

Afterburner

www.aerosociety.com

Diary

11 December 2025

Bedford Branch: FlyZero Project – Past and Future

Chris Gear, FlyZero Project Director
Aircraft Research Association, Sports and Social Club, 2000 Manton Ln, Manton Industrial Estate MK41 7PF

FlyZero was the Aerospace Technology Institute project aiming to realise zero-carbon emission commercial aviation by 2030. The project began in early 2021 as an intensive research programme, investigating zero-carbon emission commercial flight with an emphasis on liquid hydrogen propulsion. The independent study brought together experts from across the UK to assess the design challenges, manufacturing demands, operational requirements and market opportunity of potential zero-carbon emission aircraft concepts. FlyZero identified six key technology bricks which require development at pace to unlock liquid hydrogen flight, together with the enabling technologies, a sustainability assessment, operational and infrastructure requirements and economic analysis. Chris Gear, retired Chief Technology Officer, GKN and FlyZero Project Director will discuss the programme at the RAeS Bedford Branch on 11 December. ATI

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– From our President

"I wonder how many of the travelling public realise the level of effort involved behind the scenes to ensure the customer experience is world-class and, most importantly, safe."

– From our Chief Executive Officer

"We are not good at explaining to people outside of the sector the existential risks we face with a retiring workforce and a tightening of the talent pipeline."

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Message from RAeS

OUR PRESIDENT

Alisdair Wood

> I wonder how many of the travelling public realise the level of effort involved behind the scenes to ensure the customer experience is world-class and, most importantly, safe

As I write this message, we are observing the act of remembrance to honour those who served and sacrificed their lives in military conflict so that we might enjoy a peaceful and democratic life.

The act of remembrance holds profound significance, as aviation and aerospace development have been closely intertwined with military history and national defence; rapid advancements in aircraft technology were driven by the need for superior performance, safety and reliability. Engineers, pilots and technicians worked under immense pressure to design aircraft that could protect nations and save lives. Many of the technological breakthroughs made in wartime – such as improvements in aerodynamics, propulsion and materials – laid the foundation for today's commercial aerospace industries. Remembering those who contributed to these innovations not only honours their sacrifices but also reinforces the ethical responsibility of current and future professionals in aerospace to pursue progress for deterrence, peaceful and constructive purposes.

At the end of October, my own company paused for a moment of reflection for those employees who were lost during flight tests. For me this is very personal, since I could so easily have been included on the list of names had circumstances been just a little different. So, for me, the act of remembering colleagues and friends who were not so fortunate is all the more poignant.

Whilst risk and safety management have improved immensely through better techniques and modelling, there will always be a level of unpredictability as we push technological boundaries and a need for 'first-offs'. Someone has to be first and take that element of residual risk so that the rest of us can travel in safety.

In late October the British Interplanetary Society held its annual Reinventing Space conference at No.4 Hamilton Place. The conference theme was 'The Rapidly Changing Context of Global Space' and I was honoured to be asked to provide the welcome address and attend the conference itself. Amongst the many subjects discussed, a few stood out. One was the urgent need for international regulatory, legal and governance frameworks for the integration of commercial, automated and globally distributed activities. With launch costs continuing their downward trajectory, which allows many more entrants into an increasingly congested environment, it is imperative that we have legally enforceable rules, although implementation may prove to be challenging. Another subject that stood out, and one close to my themes for this year, was the recognition that the 'next-gen' skill set required is broadening with autonomy, AI and increasingly complex space missions being highlighted.

▲ The President with members of the RAeS UAE Branch for the Sir Maurice Flanagan Named Lecture. From left to right: Vimal Vijayakumar (Branch Secretary), Carl Holt (Branch Chair), the President and Ayesha Jawwad (Young Persons' Representative). Tim Robinson/RAeS

It was a pleasure and an honour to deliver the Sir Maurice Flanagan Named Lecture at the UAE Branch in Dubai, coinciding with the Dubai Airshow. This year marks the 40th anniversary of Emirates, the airline founded by Sir Maurice, adding additional significance to the lecture. The Branch is in good health with a dedicated and diverse committee led by Carl Holt FRAeS. My thanks to Carl and Emirates for hosting me both for the lecture itself and a fantastic tour of their new, extremely impressive Emirates Network Control Center. I wonder how many of the travelling public realise the level of effort involved behind the scenes to ensure the customer experience is world-class and, most importantly, safe.

There was a fantastic buzz throughout No.4 Hamilton Place during the annual Careers in Aerospace and Aviation Live event, which saw three floors filled with exhibitors providing advice and careers guidance for so many people seeking to fulfil their vocation and deliver on their potential. Although reports vary on the estimated numbers, there is a consensus among future skills and resource reports that the aerospace sector requires over a million entrants worldwide over the next ten to 15 years. There will be numerous opportunities in all disciplines, as well as emergent skills that do not yet exist. It is readily apparent that aerospace remains a sector that still attracts talent and enthusiasm. All those who work within the sector, especially our people leaders, share the responsibility to harness and develop that enthusiasm. Based on the real sense of energy at our careers fair, I am confident that we can harness all that enthusiasm and the aerospace sector will continue to flourish.

With my last message of 2025, may I take this opportunity to wish you and your families an enjoyable and peaceful winter break and a very happy New Year. Many in our sector will be working over this period and my thoughts are with you.

OUR CHIEF EXECUTIVE OFFICER

David Edwards

> We are not good at explaining to people outside of the sector the existential risks we face with a retiring workforce and a tightening of the talent pipeline

I began writing this on my flight back from the US, where I had been fortunate to witness Sir Stephen Hillier, Chair of the UK Civil Aviation Authority, being presented with the Transatlantic Leading Edge Award by the Society's Washington Branch. The award celebrates the enduring legacy of aerospace innovation and technology co-operation between the US, the UK and related allies and it was fitting that Sir Stephen, who also led the Royal Air Force, should be this year's recipient.

The US is the Society's largest community of members after the UK and to meet so many stakeholders during my visit, despite the challenges of the government shutdown there, was incredibly valuable. I was delighted to meet James Roscoe, the Embassy's Chargé d'Affaires, during my visit, alongside key representatives from across government and industry.

Visits to George Washington University and Capitol Technology University helped me learn about next-generation opportunities in the US, which works well with the Society's ongoing work on this side of the Atlantic.

I have to record my personal thanks to Sean Doyle, CEO of British Airways, for supporting the Society with my flight. Whether it was coincidence or not, the fact that the Boeing 777 operating my flight was the Society's namesake G-RAES really did highlight the global role that the Society plays.

This past month I have been very fortunate, alongside the usual day-to-day of running the Society, to visit NATS' Swanwick Air Traffic Control centre. The last time I visited it was LATCC, and based in West Drayton – meaning it was over 25 years ago. I was introduced to the very latest technology being developed to increase safety and runway capacity, and seeing it in action on Heathrow approach was eye-opening.

A visit to the London City Airport Tower, located in the heart of Hampshire, fully remote and with visuals allowing a fully immersive experience for live air traffic controlling, really did point towards the future advances in that part of the aviation ecosystem.

Having started writing this midair, I am finishing it on the Eurostar, returning from Eurocontrol in Brussels after a strategy meeting of the Global Aviation and Aerospace Skills Taskforce, part of the ICAO Next Generation Aviation Professional project. Member states, industry and academia all came together to help embed the best ideas on recruitment and retention into all of our work.

▶ Touring Swanwick Air Traffic Control centre with NATS CEO, Martin Rolfe. RAeS

▲ The Global Aviation and Aerospace Skills Taskforce's 4th Meeting in Brussels. via GAAST

We have done an inordinate amount of talking about the existential crises we face on people and skills for decades. I am hoping to now see increasing delivery and a real shift in how we speak with one collective voice. I have a personal theory that we are a sector that's so adept at responding to challenge, which absolutely thrives on problem solving and personifies the 'get on with it' mindsight, that we are not good at explaining to people outside of the sector the existential risks we face with a retiring workforce and a tightening of the talent pipeline.

The net effect of that is that aviation and aerospace, despite being one of the largest contributors to the UK's GDP, is not in any way good at articulating our threats to others. So, perhaps our challenges are not known or understood by those outside of the sector. Maybe we need to speak more loudly?

Finally, in what seems like a mere blink of an eye, it is the time to once again thank you for your support of the Society this past year – whatever work the amazing staff team here do it is a mere fraction of the work done by volunteers in the Society's name all year and around the globe.

Collectively, we do a significant amount of good for the world, whether it is advising governments on exciting futures, helping a young person or mid-career professional find their way into our industry, or just reconnecting and supporting our network of members. When I travel around our Branches I am overwhelmed at the stories I hear from attendees about their careers, their impacts and what, even after they have laid down their tools, they learn from the Society and our generous speakers. I am truly grateful to you all for continuing to keep the Society relevant and in incredible shape.

My thanks to you all – and, if you are celebrating, a very Merry Christmas. All the very best wishes for a productive and peaceful 2026.

Book Reviews

INTERSTELLAR TRAVEL AND BEYOND

Starbound: Interstellar Travel and the Limits of the Possible

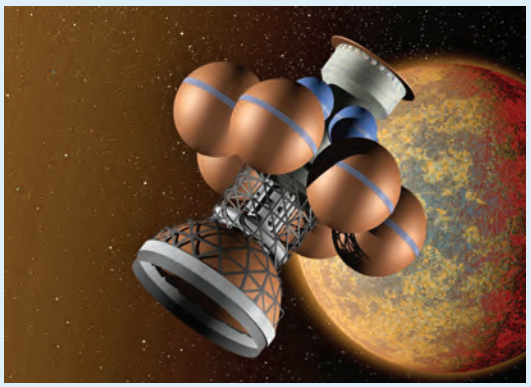
Dr Ed Regis

Cambridge University Press, 2024, 300pp, colour, £25 (hardback) or £20 (Kindle). Available as an ebook and in hard copy format via the National Aerospace Library.

Although he quotes Arthur C Clarke in the preface, this is no novel. Science writer, Dr Ed Regis addresses travelling to the stars, which is theoretically possible. "The question is whether it is possible in practice," he writes in the preface, "in a reasonable, doable, feasible, real-world and practical sense. That is the question to be addressed at length in this book." That question is daunting: to date, we have flung small probes at asteroids and planets, and landed just ten people on the Moon but no one on Mars. Our nearest star, Proxima Centauri, is four light years away. NASA's Voyager probes would need some 73 millennia to get there, a flea-hop in our hundred-thousand-light-year-wide galaxy.

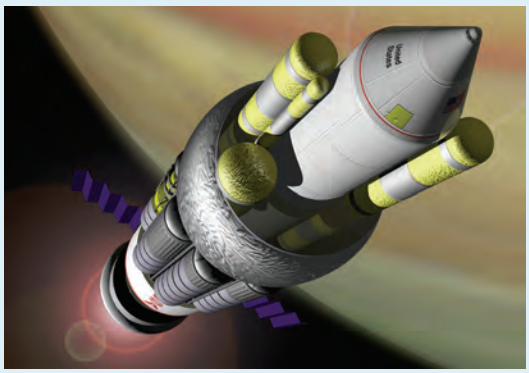
The author continues with the myths of starflight from the ancient Egyptians and Greeks, through to the Montgolfier balloonists, the Wright brothers and the Russian rocket pioneer, Konstantin Tsiolkovsky, culminating in the ambitious, joint NASA-DARPA '100-Year-Starship Initiative' in 2010.

Adding engines to a space station seems logical, so Regis presents the Bernal Sphere (1929) and the O'Neill colonies of the 1970s. Robert Bussard's ramjet was a possible engine candidate, its fusion reactor fed by hydrogen scooped from the interstellar medium (1960). Regis also describes the Daedalus concept of the 1970s, an uncrewed starship destined for Barnard's Star, proposed by the British Interplanetary Society. A whole chapter is dedicated to Project Orion of the 1950s and another to engines. The latter covers nuclear fusion, including the experimental work at Europe's CERN and the US' NIF.



◀ Project Daedalus was a 1973-1978 study conducted by the British Interplanetary Society to design an uncrewed interstellar probe for scientific research. The design criteria specified that the craft had to use existing or near-future technology and be able to reach its destination within a human lifetime. This design, from a team led by Alan Bond, proposed using a fusion rocket to reach Barnard's Star – 5.9 light years away – in 50 years. Diego bf109/WikiCommons

However, shortcomings became rapidly clear. The space colonies were limited by the available materials that their sheer enormity would demand. O'Neill colonies were dismissed by the US Senate as a "nutty fantasy." Regis describes the projected $10tn cost of a possible starship as "a stab in the dark" and, with crew sizes of 400-700,000, O'Neill was "evidently pulling numbers out of a hat." The stellar ramjet intake would have been vast (the book mentions sizes from 37 miles to 1,200 miles and as much as half a light year). Daedelus requires not merely industrialising the Earth, but also the Solar System, needing helium-3 fuel mined from Jupiter's skies. Orion, which detonated nuclear bombs at the rear of the starship, propelling the craft using explosive pressure against a shock-absorbing heat shield, is described as "by common consent the craziest interstellar flight concept ever devised." One space-time propulsion concept was researched by Cardiff-based physicist, Miguel Alcubierre, who accepts that his theory has a number of intractable problems.



▶ Project Orion was a joint NASA, DARPA and USAF study into the viability of a nuclear pulse spaceship that would be directly propelled by a series of atomic explosions behind the craft. NASA

In parallel, fusion remains unviable, still consuming more energy than it generates. Anti-matter (familiar to *Star Trek* fans) is hindered by its real-world production (CERN can produce just one nanogram annually). An alternative system, a laser-pushed lightsail, would be huge, and would demand some 75,000 times the power output of the whole world.

"It is difficult to know what to make of all this," Regis writes, "other than to say that these are some of the most alarming and unrealistic thoughts ever conceived... by serious scientists." However, to dismiss Regis as a spaceflight-hating flat-Earther is unfair. He praises the 2020 work of Hein *et al.*, who "undertook what is arguably the most... impressive review and assessment of multigenerational starship concepts produced to date." Regis is strongest when most objective, when giving the reader cold, hard numbers to contemplate.

Neither is his book an anti-nerd's dismissal of the engineering depicted in science fiction. The film *Passengers* (2016) and the novel *Aurora* (2015) are used to illustrate the problems of extra-solar

space travel, from on-board technical failures to interpersonal conflicts.

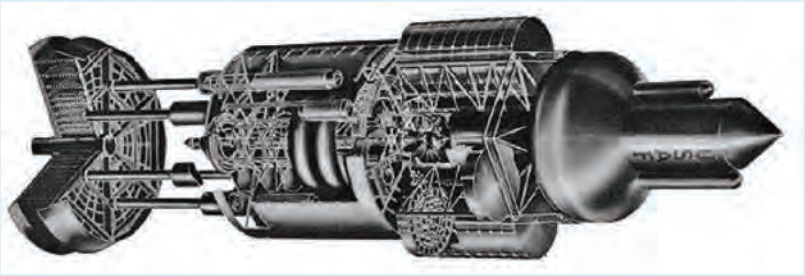
He also considers the ethics of sending perhaps thousands of people into space. Those embarking on the journey of several centuries will have chosen to do so; their ship-born descendants will not have. The author rightly challenges the more idealistic reasons, fondly cited by politicians, for space exploration, namely that it is destiny or in our genes.

A starship still lacks an obvious destination – only 5% of the 5,000 known exoplanets are Earth-like and these are between 11 and 1,100 light-years away. The eco-warriors' protest is confirmed by astrophysicists: there really is no Planet B.

Years of weightlessness would also waste bones and muscles so a radiation-shielded, rotating, crew module would be required. Regis considers hibernation, while wisely avoiding the dubious science of cryonics, and sticks to medically recognised examples of human hibernation. Because the top 20 candidate planets orbit cool, red dwarf stars, habitability would require astronauts to be genetically modified with infrared vision and photo-synthesising green skin. "These are not humans," notes Regis, "but are instead a species of post-human monsters."

Given the range and complexity of the problems, buttressed by the ten-page bibliography, it is clear there is minimal chance of mutated humans travelling through interstellar space on country-sized starships, propelled by energies – and bank accounts - thousands of times greater than the combined resources of Earth. Assuming the craft remains intact and functional, the starving, diseased and perhaps heavily factionalised crew will land on a dark world, only a handful of light years away.

Although Regis jumps between different eras, the order of his arguments is logical, if not chronological. Some of the distance and time calculations look confusing, perhaps prompting readers to check the numbers. Diagrams are sparse, even though they would have clarified the sizes of potential starships or the distances they might traverse. Some readers will disagree with certain descriptions, for example the Dyson sphere, which Dyson said would be smaller and more fragmented than Regis describes.



▲ Project Orion was based on Polish-American physicist, Stanislaw Ulam's classified 1955 paper proposing the use of nuclear fission bombs, "ejected and detonated at a considerable distance" for propelling a vehicle in outer space. NASA

Yet the author's conclusions stand; the distances are vast, the travel times measurable in millennia. The year 2001 bore little similarity to Stanley Kubrick's *2001: A Space Odyssey*. Based on this book, interstellar flight will not resemble Christopher Nolan's *Interstellar*. The near future will not be *Star Trek*, but star-bound – bound to our Sun.

Regis writes with a piercing clarity that informs us of his conclusions – and perhaps unsettles us with them as well. One takeaway is that this story is not far too bleak but far too soon. Current technology is simply not adequate, and technology that is may well be – as Arthur C Clarke would have put it – indistinguishable from magic. "The truth," Clarke once wrote, "as always, will be far stranger."

Dr Andy Sinharay MRAeS

FROM THE ARCHIVE

Working as aerial co-ordinator for the 1969 film *Battle of Britain*, former RAF Pathfinder pilot, Gp Capt Thomas 'Hamish' Mahaddie, DSO, DFC, AFC, FRAeS earned a reputation for authenticity. He scoured the world for Spitfires and Hurricanes that could be made airworthy for filming, acquired a large number of Spanish Hispano HA-1112 Buchons to play the Luftwaffe's Messerschmitt Bf109s and even leased Spanish licence-built Heinkel He-111s (CASA 2111s) and painted them in WW2 German markings. However, when it came to the Junkers Ju-87 Stuka, the only option initially available was to restore the RAF Museum's rare static exhibit. Deemed unfeasible, he then turned to Viv Bellamy at the Hampshire Aeroplane Club and asked him to transform three Percival Proctor light aircraft into replicas of the famous divebomber. Although three (G-AIAE, G-AIEY and G-ALOK) were intended to be converted into 'Proctukas', only two were completed and only 'EY (ex-P2667) was flown. Bellamy reportedly referred to it as a "deathtrap" and plans to use it for filming were abandoned in favour of using radio-controlled model aeroplanes. Today, a pair of original Junkers Ju-87s are under restoration to fly, one in the US and one in Sweden (albeit for a US-based owner). NAL/RAeS

For daily historic aviation content see the 'On This Day in History' feature on the Society's Facebook and LinkedIn pages.

Society News

HUMAN FACTORS RESEARCH & BENCHMARKING

The International Ergonomics Association defines human factors as "the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimise human wellbeing and overall system performance."

The RAeS Human Factors Specialist Group need your help. We need your help to identify human factors and ergonomics topics of interest to improve knowledge and understanding of the discipline that may lead to human performance improvement in the aviation, aerospace and space sectors. The group is also keen to understand ways in which these knowledge 'gaps' can be fulfilled in the future – through webinars, conferences or one-day workshops, etc.

As such, an online study has been compiled and we would be grateful for responses (from members and non-members alike). The survey is completely confidential with all responses aggregated and anonymised. No personal data will be shared. The survey comprises only 12 questions and should take no longer than approximately ten minutes to complete. The survey is open from now until 31 December 2025 and can be accessed via app.onlinesurveys.jisc.ac.uk/s/bham/raes-hf-survey2 or by scanning the QR code.

For further information please contact m.a.bromfield@bham.ac.uk.

Dr Mike Bromfield FRAeS
Chair of Human Factors Research & Benchmarking Group

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Diary

EVENTS

2 December
RAeS/Protolabs Webinar 2025 – The State of Aerospace Manufacturing in 2025: Navigating Sustainability, Skills, and Defence Growth
Thibaut Jeannerot, Senior Strategic Application Engineer at Protolabs, Michael Hawkes, Engineering & Support Director at Safran Helicopter Engines UK, other key industry members. Moderated by *AEROSPACE*'s Stephen Bridgewater
Online via MS Teams (10.00-11.00 GMT)

3 December
Belfast Branch: Life in the Pit Lane
Bernie Collins, McLaren and Aston Martin Formula 1
Sir Bernard Crossland Lecture Theatre, Ashby Building, Queen's University Belfast Stranmillis Road, Belfast BT9 5AG

3 December
Weybridge Branch: 70th Rex Pierson Lecture: Another giant leap for mankind
Padhraic Kelleher FRAeS, UK CAA Senior Adviser
Brooklands Museum Clubhouse, Brookland Road, Weybridge KT13 0QN

3 December
North Wiltshire Branch: Hunter Technical Details
Rod Dean, Aviation Consultant
The Deanery CE Academy, Swindon SN1 7DA

3 December
Cambridge Branch: No 51 Squadron and Airborne SIGINT Aircraft
Air Commodore Bill Tyack CBE FRAeS FRIN
Cambridge Museum of Technology, Cheddars Lane, Cambridge CB5 8LD

4 December
RAeS Wilbur and Orville Wright Named Lecture 2025
Dr Michael Winter, Chief Scientist, RTX
Royal Aeronautical Society HQ, No.4 Hamilton Place, London W1J 7BQ

8 December
Prestwick Branch: Taking Part in the 'Pooleys Dawn to Dusk' Competition
Derek Pake
University of the West of Scotland, Ayr Campus, University Avenue, Ayr KA8 0SX

9 December
Yeovil Branch Christmas STEM event and Lecture
Subject & Speaker TBC
iAero Centre, Leonardo Helicopters Airfield, Bunford Lane, Yeovil BA20 2GL

9 December
Loughborough Branch: Buccaneer through the archive
Room U0050, Brockington Building, Loughborough University, Margaret Keay Rd, Loughborough LE11 3TU

9 December
Farnborough Branch: Life in the cockpit – from Grasshoppers to Harriers
Group Captain Chris Burwell MBE RAF (Retd)
Farnborough College of Technology, Boundary Road, Farnborough GU14 6SB

9 December
Southend Branch: Southend Airport in the 1950s and 1960s
Holiday Inn, Southend Airport SS2 6XG

9 December
Chester Branch: The North American Mustang
Rod Dean, Aviation Consultant
Broughton Wings Club, Chester CH4 0NQ

9 December
Hatfield Branch: eVTOLs Under a Microscope – Engineering and Certification Challenges for Distributed Electric Propulsion
Dr Rashid Ali FRAeS
Lindop Building, University of Hertfordshire, Hatfield AL10 9AB (and online)

10 December
Preston Branch: Development of Jaguar
Speaker and Venue TBC

10 December
Brough Branch: Skylab - NASA's Often Forgotten Triumph
John Dunthorne, Chairperson of Cleethorpes and District Astronomical Society
Cottingham Parks Golf & Leisure Club, Woodhill Way, Cottingham, East Yorkshire HU16 5SW (& online)

11 December
Manchester Branch: Avro's Role in the Dambusters Raid
Frank Pleszak
Avro Heritage Museum, Chester Road, Woodord, Stockport SK7 1QS

11 December
Munich Branch: E-aircraft – system design and certification
Pablo Gutierrez Electric Aviation Consultant. PG-AEC and Dr Sebastian Seemann, CTO Aircraft Design Certification GmbH
TUM Campus Garching, MW 1801, Boltzmannstraße 15, 85748 Garching bei München

11 December
Bedford Branch: FlyZero Project - Past and Future
Chris Gear, Retired CTO at GKN and FlyZero Project Director
Aircraft Research Association, Sports and Social Club, 2000 Manton Ln, Manton Industrial Estate, Bedfordshire MK41 7PF

11 December
Birmingham, Wolverhampton and Cosford Branch: Chinook in the Falklands
Richard Setter, former 18 Sqn Chinook RAF Technician.
RAF Museum Midlands, Shifnal TF11 8UP

18 December
Munich Branch Willy Messerchmitt Memorial Lecture: GCAP – Developing the Future of Combat Air
Herman Claesen, Managing Director, Future Combat Air Systems at BAE Systems
TUM Campus Garching, MW 1801, Boltzmannstraße 15, 85748 Garching bei München

2026

12 January
Manchester Branch: Piloting Concorde
Captain John Hutchinson
Manchester Runway Visitor Park, Sunbank Lane, Altrincham WA15 8XQ

12 January
Prestwick Branch: Right Place, Right Time for a New Scottish Built Fast Jet Trainer
Archie Neill, UK Strategy Director, AERALIS Ltd
Lecture Theatre 2, University of the West of Scotland, Ayr Campus, University Avenue, Ayr KA8 0SX

13 January
Farnborough Branch: Winkle – Flying German Jets
Paul Beaver FRAeS
Farnborough College of Technology, Boundary Road, Farnborough GU14 6SB

13 January
Loughborough Branch: SaxaVord Spaceport in Shetland
Ruaraidh Galbraith, Launch Campaign Asssistant, SaxaVord Spaceport
Room U0050, Brockington Building, Loughborough University, Margaret Keay Rd, Loughborough LE11 3TU

14 January
Chester Branch: Helicopter Search and Rescue
Paul Treth, Civilian and Military Winch Operator
Broughton Wings Club, Chester CH4 0NQ

14 January
Marham Branch: Virtual Visit to Pima Air & Space Museum
Speaker TBC
Marham Village Bowls Club, Coronation Playing Field, King's Lynn PE33 9JQ

15 January
RAeS Lecture: Laser and RF Directed Energy, a complement to kinetic effects
Dr Mark Owen, Head of Laser Directed Energy for MBDA
Royal Aeronautical Society HQ, No.4 Hamilton Place, London W1J 7BQ

15 January
Birmingham, Wolverhampton and Cosford Branch: Comet Disasters
RAF Museum Midlands, Shifnal TF11 8UP

6 February
RAeS Lecture: eVTOL Aircraft Preliminary Design & Validation – A Case Study
Prof Mike Bromfield
Royal Aeronautical Society HQ, No.4 Hamilton Place, London W1J 7BQ

For further information and booking, visit **aerosociety.com/events-calendar/**

Society News

WHAT REALLY HAPPENED TO CONCORDE?

◤ A packed audience at the Weybridge Branch meeting at Brooklands Museum on 10 September. Paul Robinson

◥ Air France Concorde F-BTSC, which was lost in the tragic accident at Gonesse in July 2000. NAL/RAeS

Perhaps it was the title, suggesting that 'beans might be spilled' which attracted the largest audience for some time to Brooklands Museum on 10 September for this Weybridge Branch talk about the only fatal Concorde accident, which occurred 25 years ago.

The speaker was Alan Simmons, a former UK AAIB Principal Inspector, now retired. Simmons began by asking why the Concorde still held such a fascination for the British and French public. He then explained that his purpose was to show that, while the investigation uncovered many well-established facts, there had always been some gaps in our understanding. Where, in some cases, there was little hard physical evidence and possible alternative explanations, these gaps had eventually been addressed by testing and research, which provided highly plausible explanations as to why there was so much damage and an intense fire. During the investigation, sufficient evidence was uncovered to allow a practical and effective modification programme to return the aircraft to service, even if some elements and the sequence of events were disputed.

The lecture included a brief history of the speaker's involvement with the Concorde over many years, describing how he came to be appointed by the UK AAIB to assist the French authorities with the engineering aspects of the investigation into the accident in the Gonesse suburb of Paris on 27 July 2000. He then outlined the hard evidence available in the first few days from debris on the runway and along the flight path, together with that found on the accident site. Then began the long, and at times difficult, process of piecing together the available evidence. Simmons pointed out that there was no direct evidence of tyre, or anything else, hitting the underside of the wing, mainly due to a lack of wing debris recovered. The proximity in time of the tyre burst and tank rupture made a link between the two inescapable, but the investigators searched in vain for the impact site. The mechanism for the tank rupture described in the French report is entirely plausible – but was only one of several possible mechanisms, and in an addendum to the report the AAIB pointed out that at least one other possibility had not been adequately investigated.

Further, the fleet history gave no indication that a tyre burst, alone, could cause so much damage. Unfortunately, some pertinent technical records were not available to the investigators. A manslaughter investigation by the French Judiciary did not help this situation. Since the provisions of ICAO Annexe 13 were not followed in full, this also was reflected in the AAIB's official comments. Eventually the Judiciary prosecuted a (then retired) Aérospatiale senior designer and an American mechanic without success.

There was also dissent about the mechanism by which the leaking fuel was ignited, which was finally resolved, at least to the satisfaction of the AAIB, by spectacular full-scale wind tunnel testing using real fuel and sparks. This was the mechanism accepted and eventually published in the French report.

While there were numerous difficulties and challenges during the investigation, there was sufficient clear evidence to enable practical and effective corrective actions to be carried out, ultimately resulting in the aircraft successfully returning to service with both British Airways and Air France.

In spite of a belief in some quarters that the accident finished the Concorde story, it was actually the succession of a number of other events, including epidemics, terrorism and friction between the US and France, which resulted in declining transatlantic traffic, especially for Air France. Eventually Airbus (France), Snecma and Air France withdrew support which left the British 'holding the baby', which was not tenable.

The tragedy is that there was never a successor to Concorde. Whether it was lack of technology, materials, engines, or just vision, there was not, and still is not, anything to rival it.

A large and appreciative audience engaged in a lively question time which was eventually drawn to a close by the Branch Chairman, John Dunne.

Paul Robinson MRAeS
Weybridge Branch

Society News

THE GERMAN INFLUENCE

On 25 September, former BEA and British Airways Training Captain, Dacre Watson, provided the latest Aeronautical Heritage Specialist Group lecture at No.4 Hamilton Place.

Titled 'Airlines in South America 1920-1942: The German Influence', his presentation looked at how Germany dominated the region's airline sector during the interwar years.

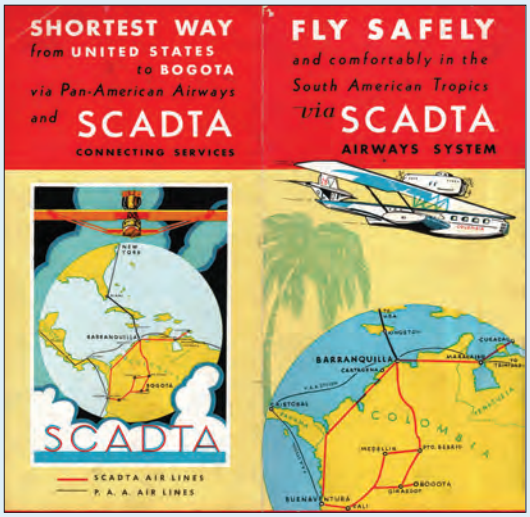
Following defeat in WW1, Germany had very onerous restrictions imposed upon it by the Treaty of Versailles – including limitations on aircraft and aero-engine production, as well as the loss of its colonies. Thus, while the victorious European nations developed air routes to their colonies, Germany was forced to look elsewhere to release its aeronautical experience. South America proved attractive, given large ethnic German populations in many of the region's countries.

Colombia was the first to benefit from the relationship with Germany. Operations by *Sociedad Colombo Alemana de Transportes Aéreos* (SCADTA) began in 1921, cutting the journey time from the port of Barranquilla to the capital, Bogotá from ten to fourteen days to ten hours.

The founder of SCADTA, Dr Peter Paul von Bauer, worked with German company, Condor Syndicat, a trading firm set up in Berlin in May 1924 for the exclusive purpose of promoting the sale of German commercial aircraft overseas. While von Bauer's airline was successful, extending to Ecuador by 1928, it caught Juan Trippe's attention. After the Wall Street crash, Trippe approached von Bauer offering to 'help' him by acquiring 50% of SCADTA and taking over the airline's routes outside of Ecuador. The shareholding was increased to 84% in 1933. The most extraordinary thing about this deal was that it was kept secret by Trippe and von Bauer for many years.

In Bolivia, Junkers set up Lloyd Aéreo Boliviano (LAB) in 1925, operating Junkers F-13s. Although legally independent of Luft Hansa, it was seen as a subsidiary, operating German aircraft supported by both German personnel and the German-owned Sindicato Condor in Brazil. Luft Hansa expanded into Peru in 1938 operating Junkers Ju 52 aircraft. In Brazil itself, Condor Syndikat (subsidised by Luft Hansa) flew from Buenos Aires to Rio de Janeiro in 1926 and, as a result of this flight, in January 1927, Condor Syndicat was granted a one-year authorisation to operate air services in Brazil. Although Condor Syndicat officially ceased operations in July 1927, Syndicato Condor, the new Brazilian company, simply continued.

▲ The lecture was lavishly illustrated with period travel posters, maps and images. NAL/RAeS



Notwithstanding strong German influence within South America, Trippe's Pan American Airways' inexorable growth continued. Following his 'deal' with SCADTA, and after disposing of Ralf O'Neill's New York Rio and Buenos Aires Airways (NYBRA) – thus gaining control of the east coast of South America – he formed a joint venture with WR Grace Shipping Line to establish Pan American Grace Airways (PANAGRA) to dominate the west coast.

However, public sentiment and pressures from the US were too great to be ignored. Following the start of WW2 in Europe and subsequent Japanese attack on Pearl Harbor, German influence was finally removed from South American airlines.

Watson's lecture also addressed transatlantic mail services. This was first conducted by Dornier Wal flying boats to Brazil's Fernando de Noronha archipelago in the Atlantic, where the mail would be transferred to a fast ship for onward carriage to Las Palmas in Gran Canaria and on to Germany.

In 1934, Wals flew to a ship in mid Atlantic, landing on the ocean before being winched aboard, refuelled and then catapulted off to continue their journey.

Also covered in the lecture were the Zeppelin passenger services from an experimental flight in 1930 to 16 round trips in 1935.

This lecture encompassed a little-known area of aeronautical history in exemplary detail marvellously enlightened by a superb range of photographs, maps and contemporary marketing collateral. Watson will prepare a paper, based upon his lecture, for the Society's *Journal of Aeronautical History*.

◀ Capt Dacre Watson addresses the audience at the No.4 Hamilton Place on 25 September. Nigel Dingley

Nigel Dingley MRAeS
Aeronautical Heritage Specialist Group

Elections

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Agenson Ameh
Phillip Ashley-Smith
Patrick Blair
Chris Bosworth
Nigel Bradshaw
Neil Canavan
Gosta Centerwall
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James Cole
Barbara Courtney
Romina Davoudi
Rajib De
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Nese Edgar
Garry Ellingham
Shaojun Feng
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Emma Hatton
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Wendy Morse
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WITH REGRET

The Royal Aeronautical Society announces, with regret, the death of the following members:

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Bernard Christopher Staples MRAeS 74
Norman Taylor FRAeS 85
Richard Landeg Williams AMRAeS 92

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New Member Spotlight

CAROL MARSHALL

Name: Carol Marshall

Grade: Member

Age: 52

Location: Portsmouth

Job title: Principal Engineer – DSTL (Defence Science and Technology Laboratory)

What inspired you into aerospace? When I was at school, I joined an engineering club where one challenge was to build a toy car and roll it down a ramp. It sounded easy but the requirement was to make the car roll as slowly as possible using a combination of gearing and elastic bands. I was determined to come first, and I did, through determination and persistence. This started a love of engineering and from that point onwards, I decided that this is what I wanted to do as a career. I involved myself in as many engineering opportunities as possible, including 'girls in engineering sessions' and completing work experience at a small engineering firm manufacturing gears and pulleys. I grew up in an area where there was a strong aerospace engineering presence, so when I left school, I was successful in applying and completing an aerospace apprenticeship in the airframe/engine discipline. I absolutely loved it and not only was I learning precision aerospace engineering but learning so many life skills in the process. This has been the foundation block of my career and one that I would not change at all. Through my career I have worked across rotary-wing, fast jet, aero engines and even missiles in varying roles.

What's the best thing about your current role? I am fortunate that I am involved in a variety of complex rotorcraft projects spanning science and technology, research, innovation and exploitation at a multinational level. One of my tasks includes providing specific subject matter expertise for a next-generation multirole rotorcraft at an international level. It is a fantastic opportunity for me to help influence and support the creation of requirements during the concept phase of a high-visibility programme. This is a pivotal chance to develop a capability to fulfil a number of different operations over the land and maritime domains with a very complex and challenging attribute list. I am also involved with multinational science and technology organisations where we work together to identify, develop and support specialist activities – for example, providing solutions for potential capability gaps, development of standards, conducting feasibility studies and providing evidence to support informed decisions in the aeronautical domain. This has led to working with some amazing people who have taught me so much. I relish getting to know like-minded individuals, learning from their experiences and building great working relationships.

What made you join the RAeS? Joining the RAeS allows me to keep doing what I love, meeting new people, sharing experiences and knowledge. It is an institution built on a foundation of history and has grown to be a well-respected community of specialists. It is the icing on the cake for me; the RAeS represents everything I have built a career on.

What do you hope to get out of your registration with the RAeS? Firstly, I would like to expand my network, exploit the opportunities that the RAeS can offer and keep building my knowledge base. There are so many interesting members and I feel privileged to be part of such a historic association and community. Support, advice and mentorship are something that the RAeS can provide and, most importantly, it allows me to give back through inputting my experience and knowledge to other members. Secondly, I want to obtain Chartered Engineer status. This is something that will optimise my career and I feel that the RAeS is best placed to support that process towards my next career goal.

What three items would you take with you to the space station? It may be a cliché and the first thing everyone would pick but I would take a camera. Secondly, my kindle as reading is my relaxation method to disengage my brain at the end of a day. Finally, lots of different kinds of music as I have eclectic tastes, although I would definitely have some 'space' themed ones in the playlist!

Who is your biggest inspiration? Without a doubt, my Mum. She truly inspired me to be the person I am today, instilling some key values to live by, including working hard to achieve your goals, treating people how you wish to be treated yourself and always doing the right thing. She was so supportive of my choice in career, despite maths and science never being my strongest subjects at school! She always encouraged me to follow my dreams and I know she was proud of all my achievements throughout my career. I also want to acknowledge the many engineers and scientists who I work with; they are truly inspirational to me, and I am always in awe of what we can all achieve to ensure we fully support and keep safe our customers. The technological advances and the desire to keep growing and evolving capabilities is fantastic and one thing I am very proud of.

Piece of advice for someone looking to enter your field? Seek out and take every opportunity available to you; you never know where you may end up. It may push you out of your comfort zone and it may or may not always work out but you will learn from it and gain valuable experience, whatever happens. Never regret going for opportunities as you may regret not going for them in the end!

The Last Word

COMMENTARY FROM

Professor Keith Hayward
FRAeS

Copying the Airbus model

Europeans should rightly celebrate the fact that, in terms of sales, the Airbus A320 has overtaken the Boeing 737 as the most successful jet airliner in history (someone might tell me if it has beaten the civilian DC-3 Dakota on the all-time list). I have described the scale of these achievements many times in the past and what a near-run thing the entire survival of the Airbus consortium was. Explaining how, in general terms, Europe pulled off this trick demands attention to some complex economic and political history from 1945 onwards.

European success

As Ben Franklin said in a very different context, "we hang together or assuredly we shall hang separately," it was perhaps the primary force pushing the Airbus partners together and surviving some powerful centrifugal forces. To quote another politician entirely: "there (was) no alternative." Despite the 1939-45 war, European industry retained enough capability and capacity into the 1950s to establish a base – and with due praise, UK technological innovation in key areas and its untouched wartime base. Aerospace could piggyback wider integrative forces; the UK's interest in Concorde and initially Airbus was motivated by attempts to get into the EEC.

Leaders don't need partners

There is a similar soup of factors, with added cultural variables explaining why other regions have not gone down the European route. The US is easy – it never had to bother. Boeing and, before the merger with McDonnell Douglas, had international partners with varying degrees of risk sharing and design autonomy, but there was never any doubt which firm was the boss. This was one of the main reasons why British Aerospace resisted the siren call (and Whitehall pressure) to work with the Americans on airliners.

So why not an Asian Airbus? The geography is harder but, as Airbus showed, an airbridge, even if expensive, can work very well indeed. In some respects, it works better than transporting large sub-assemblies by rail exposed to random acts of vandalism or just rough usage. The most likely set of reasons stem from post-War political history. Only Japan had a base industry comparable to Europe, but wartime destruction and a decade of prohibited activity constrained recovery. Then constitutional limitations hampered the defence sector. Close relations with the US also compelled buying from American companies. Domestic civil projects were total commercial failures.

China has built an impressive domestic capability, albeit in airliners still dependent on foreign suppliers. Co-operation could help speed up expansion, but links with Russia have so far proven a weak reed. Politically, China stood at the other end of the bipolar world, and the 'Chinese threat' now has even more resonance. Finally, unlike Germany's recovered relations with its neighbours, Japan's wartime depredations have continued to linger in many Asian countries, with co-operation with Japan still a sensitive question for many people.

Other Asian countries have begun to create impressive aerospace and aerospace-related skills. There is certainly no shortage of human resources or powerful companies. Some, such as Taiwan, might have been drawn into working with McDonnell Douglas. South Korea is a well-established subcontractor, particularly in on-board entertainment systems. The region scores highly on process technology and quality build. However, in many cases there are easier and more profitable arenas for investment than civil aerospace. In many cases, the focus for national aerospace ambitions has been the development of indigenous combat aircraft, which may or may not form the basis for a successful entry to world markets. Civil projects will, of course, confront the 'Big Two' and Embraer, whose commanding presence in the market will create an additional barrier to entry, even for China. The line of least resistance tends to be collaboration with Airbus or Boeing, not with the neighbours.

> "THIS WAS ONE OF THE MAIN REASONS WHY BRITISH AEROSPACE RESISTED THE SIREN CALL (AND WHITEHALL PRESSURE) TO WORK WITH THE AMERICANS ON AIRLINERS

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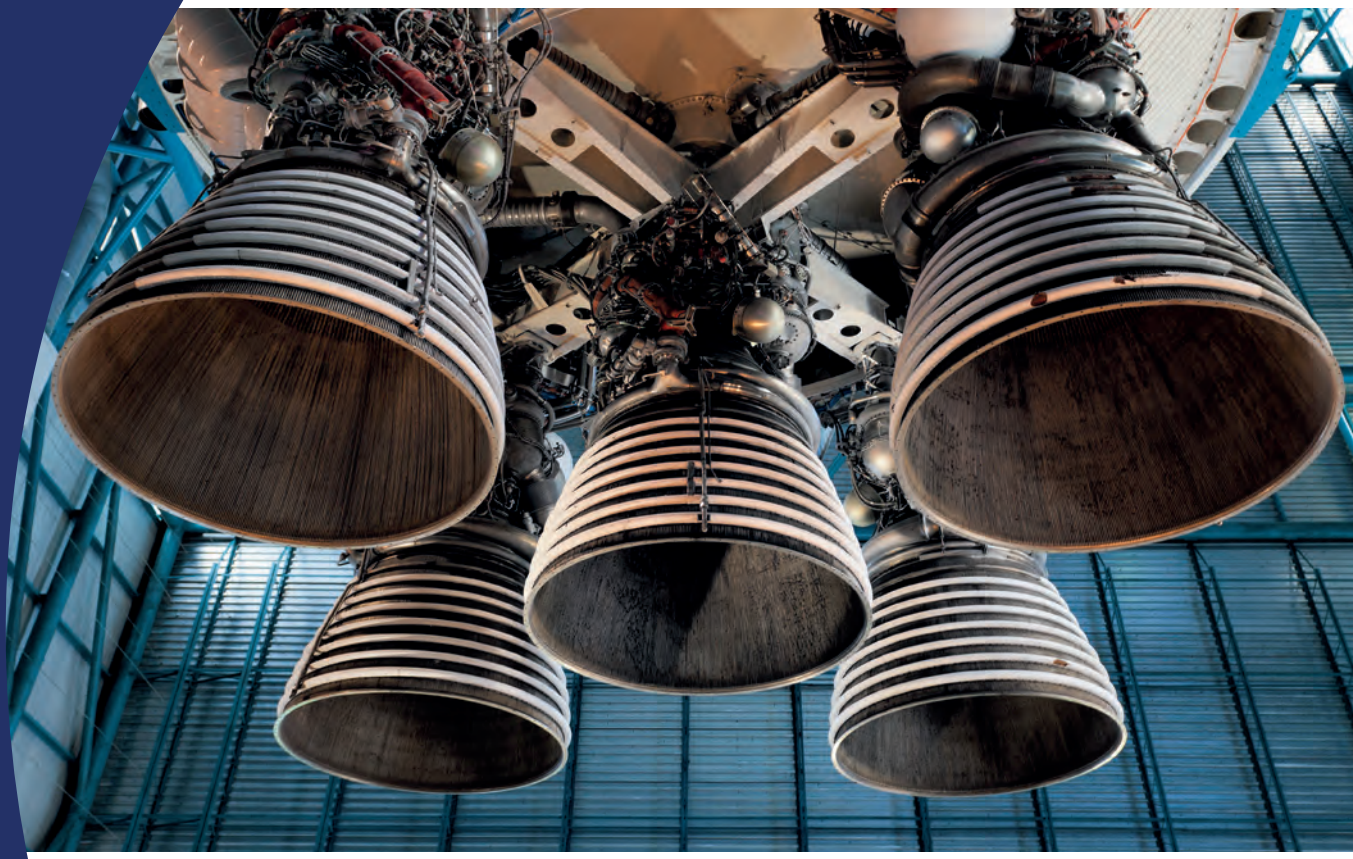

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